Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VI. NEW YORK, JUNE, 1901. No. 4.

VIEW OF DREDGE "CHAMPION" EQUIPPED WITH PNEUMATIC CLAMSHELL BUCKET.

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OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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A friend and subscriber of COMPRESSED AIR living in Berlin, who is the President of the Board of Directors of a large German iron foundry, recently gave copies of COMPRESSED AIR to the chief engineers of his establishment and requested them to examine into the possibility of using compressed air appliances in their work. He sends us translations of their replies, and remarks that the opinions were given independently of each other "and rather surprised me and will doubtless also surprise you." We give their replies exactly as they were received by us, because they represent the opinions of a large number of foreign engineers.

In view of the very large use of pneumatic tools of various sorts in this country these letters are of great interest, showing, as they unmistakably do, the indifference with which even educated foreign engineers are wont to regard labor-saving machines.

Through both letters there is an undercurrent, which, if read aright, shows a self satisfied "Oh-you-can't-improve-on-us" tone which, if persisted in, will sooner or later result in this concern taking a back seat.

In addition, these letters show a striking lack of appreciation of the principles involved and the possibilities of increased output, reduction of hand labor and improvement in character of work resulting from the use of pneumatic apparatus, the value of which has been definitely established by hundreds of examples in this country.

We suggest that some of our readers interested in the manufacture of this class of apparatus answer the arguments advanced by the two German engineers.

First letter:

1. The use of pneumatic hoisting appliances in our works is out of question, as we possess everywhere mechanical or electrical hoisting apparati. The pneumatic hoisting tools must be suspended on cranes and are meant to replace the windlasses on traveling or turning cranes.

2. *Pneumatic Hammers.* — These are used to advantage, as one hears, for cleaning castings. The introduction of same can, however, only take place practically with the introduction of a pneumatic plant in the boiler shop, as the equipment when only meant for cleaning castings would hardly prove profitable. The opinion as to the advantage of pneumatic hammers varies, whilst on the one side it is asserted that the workmen cannot stand for long the concussion in the muscles of the arm, this point is disputed on the other side.

3. *Pneumatic Drills.*—The same have no advantages over the electric drills and can, according to my opinion, only be used where there is a pneumatic and no electric plant at disposal.

4. *Pneumatic Sand-Rammers.* — These sand-rammers likewise must be suspended on cranes and would require in our work shop a traveling crane for themselves. They can only be recommended for the ramming of large pieces as the prepara-

tions for the connection of the air tube and for the connection and disconnection of the apparatus itself, etc., would eliminate otherwise the advantages obtained by saving of labor.

5. *Sand Blasts.*—These blasts are only profitable, when great quantities of small castings are manufactured, because the castings to be cleaned must be placed in the machine, which makes them pass the blast.

6. *Sand Sifters.*—Pneumatic sand sifters are not known to me.

7. *Casting Machines.*—I suppose pneumatic traveling cranes are meant with these machines, instead of which electrical or hand cranes are used in our works.

8. *Pneumatic Paint-Machines.* — These are said to be very efficient and answer very well, when there are large surfaces to be painted, especially in bridge building factories, for us they would hardly be of any use.

Second letter:

1. The use of hoisting tools for our foundry service cannot be taken in consideration, because we are provided with cranes, which permit of the lifting and lowering of casting boxes and mouldings.

2. *The Hammers* are used for chipping and cleaning the castings, but are not to be recommended for service in foundries, because the cleaner cannot stand long constant shocks, viz., the constant vibration. Such a plant would be combined with great difficulties in our Works, as large castings are cleaned in the open air, thus necessitating the use of a very long tube.

3. *Sand-Rammers.*—These are used for ramming large pieces by which an uniform ramming is obtained, which cannot be obtained by ramming done by manual work. The chief advantages of such a plant lie in the considerable saving of labor. The sand rammers are suspended on a crane and are brought over the respective piece, when the ramming can commence. During such time the crane in question is constantly required, whereby the other section of foundry is handicapped for a longer or shorter period. The use of such sand-rammers can therefore not be recommended.

4. There can only be the question of using *drills,* when there exists a pneumatic plant.

5. *Sand Blasts.*—If we decide on building a shop for cleaning castings in which likewise the greater castings can be cleaned, then the use of such blasts may be contemplated.

6. *Sand Sifters* are to be recommended, as the sand is worked off much cleaner than by a hand sieve.

7. *Casting-Machines.*—Such a machine is not known to me; probably moulding machines are meant by it. Should we decide in manufacturing small castings by the mass, then probably only moulding machines, worked by hand, would be procured and probably only two machines.

8. *Pneumatic Paint Machines* are not needed for service in foundries.

From the above it appears that the purchase of pneumatic appliances for our foundry is not to be recommended.

In another portion of this issue we give an abstract of a paper by Prof. John H. Barr, of Cornell University, in which the subject of "Multiple Stage Air Compression" is discussed in an interesting way. In this we notice that Prof. Barr speaks very frankly about some of the defects of the usual forms of mechanical valve for air compressor cylinders.

Prof. Barr's wide experience with engines places him in a position to discuss this subject in a satisfactory manner, and we feel that his statements about the difficulties of the usual forms of mechanical valves should be carefully noted.

Referring to mechanical valves in general, he says that when properly set they cause less throttling because the actual opening of a valve is independent of the air pressure in the cylinder at the moment of opening and do not, therefore, depend upon an excess of pressure to open them.

This is very true of the ordinary form of Poppet Inlet Valve, especially with small compressors where the general efficiency can never be remarkably high, because of the large part which friction and clearance must play. On the other hand, mechanical valves for small size compressors, along with the advantages which Prof. Barr allows, also include the difficulties of complication, expense and the reduction in the volumetric efficiency of the machine because of the large amount of clearance necessary in comparison to the volume of air handled.

With the large forms of compressors

the objection of throttling with spring closed inlet valves continues to some extent, and it is this objection which has caused many manufacturers to resort to the use of direct operated or mechanical inlet valve. If, however, any form of direct connected valve is used, the greatest care must be exercised in adjusting it to open at exactly the right moment or else the capacity of the cylinder is reduced to an amount which depends upon the delay in opening. This adjustment must be doubly fine, for should the valve open too soon, some of the air under compression immediately escapes back into the inlet passage and the capacity of the compressor is again reduced.

It is thus seen that twice for each stroke there is a point where all valve movements should occur, that is the instant the piston changes direction. This interval is very brief, and to secure ideal working, all air valves should operate in this time. With rigid connections this "instant action" is well nigh impossible, and generally it results in early or late closing of one or more of the four valves.

Another feature which must not be lost sight of is also mentioned, namely, the gradual opening or gradual closing of the inlet and discharge valves, causing the inlet or discharge ports to decrease in area until toward either end of the stroke the port opening is exceedingly small.

The fact that the piston gradually slows up and comes to rest somewhat balances this, but it would be far better in every way if the ports could remain full open and close instantly at the proper moment. Especially is this so on the inlet side, for here the pressure of the entering air is small and its volume consequently great, which in turn calls for a large port opening to guard against "wire drawing."

The desideratum at all times is to favor that system which, other things being equal, takes in the greatest volume of air, for this means a higher volumetric efficiency, in other words, more compressed air, which, after all, is what is wanted.

Another point too often disregarded is the liability of accident to the discharge valves when rigidly connected to the valve motion. Especially is this true in temporary plants or any installation where the load is apt to be thrown suddenly on or off. To explain this, suppose we imagine the piston near the end of its stroke. At this moment, the air ahead of it is under maximum compression and as already explained, the discharge valve is also nearly closed, leaving a very small outlet for the air to pass through.

Now, should the receiver pressure suddenly drop from any cause the valve which is designed to have maximum pressure holding it on its seat at once has all of its conditions reversed and the full pressure tending to force the valve off its seat. This strains the valve and has been known to wrench the valve motion and cause serious trouble. In any case it wears the valve motion and is a disadvantage.

Clearance which plays such an important part in the volumetric efficiency of a compressor is invariably greater with the usual forms of mechanical than with the poppet valve when properly designed.

Mechanical valves, especially of the Corliss type, leave much to be desired when it comes to cooling during compression, an item on which the efficiency and to some extent the safety of the compressor depends. The reason for this is that the heads are so largely taken up by the valves and working parts that there is no opportunity for the water to be brought into intimate contact with the parts which are in direct contact with the heated air.

While water cooled heads do not lower the temperature of the air sufficiently to make any remarkable improvement in the efficiency of a compressor, they do effect a saving in two ways. It is obvious that if the cylinder head has a sheet of water on the outside when the air is compressed against it on the other side by the movement of the piston that its temperature is held down and an accumulation of heat in the metal is prevented so that the temperature, with which the lubricating oil comes into contact, can never exceed a certain safe limit.

At the same time the air is in constant contact with the heads while, for a large part of the stroke, it is not in contact with the cylinder wall. If jacketing of the wall is desirable, in view of the longer contact with the heads it is even more desirable and in fact necessary that they be cooled.

Summing up in view of the facts stated it is apparent that the general run of mechanical valves for air compressors are not improvements over the older types of poppet valve, and in many cases they are positively defective; that a mechanical

valve which is rigidly connected to the valve motion possesses inherent defects which make it inferior to the poppet or floating valve.

A Pneumatic Clamshell Dredge Bucket.

The pneumatic clamshell dredge bucket, which we illustrate herewith, is an innovation on the usual construction of such apparatus which promises to have a wide field of usefulness. As engineers familiar with this type of dredging apparatus know, the ordinary chain-closed clamshell has important objections; the bucket can be closed only after it has come to rest on the bottom, and the pull of the closing chains reduces the effective digging weight of the bucket owing to their lifting action. To avoid these objections

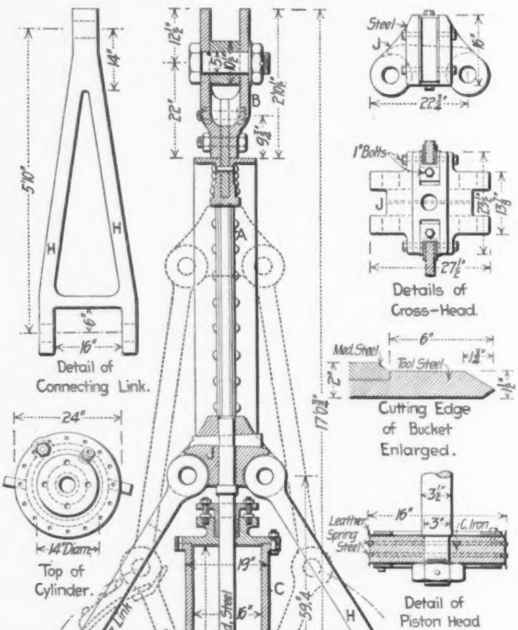


FIG. I. VERTICAL SECTION AND DETAILS OF PNEUMATIC CLAMSHELL DREDGE BUCKET.
WM. H. ARNOLD, NEW YORK, INVENTOR.

several attempts have been made to devise buckets closing by the action of liquid pressure in a cylinder, but so far none of these devices has gained much favor. The bucket illustrated here is one of the latest of these devices, and its very successful operation in the trial installation promises, as stated above, to reverse the poor success met with by previous buckets of the sort. In it the opening and closing of the bucket is performed by air pressure operating through a cylinder and piston, the action being wholly independent of the hoisting chains and of the position of the bucket.

The construction of the bucket is, perhaps, best seen from the sectional drawing, Fig. 1. The central element of the bucket is the frame, A, which terminates at the top in a fork, B, and at the bottom in a cylinder, C. Between the arms of the fork is pivoted a compensating bar, D, to the ends of which are attached the hoisting chains, and at the bottom of the cylinder is a wedge-shaped cylinder-head guard, E. The compensating bar serves to keep the bucket vertical in descending, while the cylinder-head guard serves as a means for anchoring the bucket or for holding it while filling in a fixed position in the material to be removed. The shells, F F, of the bucket are hinged to the frame by four bucket arms, G, and are also hinged to the crosshead, J, by the triangular connecting links, H. This crosshead is keyed to the top of the piston rod and slides between interior guides on the two members of the frame. Minor details of the construction are clearly shown by the drawings.

In operation, the jaws or shells of the bucket are both opened and closed by the positive action of the air pressure upon the bottom or top of the piston. The air is conveyed to the cylinder from the receiver on the dredge through a double barreled or Siamese hose arranged as described later. The full lines, Fig. 1, show the positions of the crosshead, connecting links, bucket arms and jaws when the bucket is closed, and the broken lines show these parts, for one side, when the bucket is open. It will be observed from the drawing that the opening and closing mechanism is wholly independent of the devices by which the bucket is hoisted and lowered, so that it may be opened or closed at any point in its vertical travel. Furthermore, it will be seen that when the bucket rests on the bottom its whole weight is effective for digging, the hoisting chains remaining slack until the jaws are closed.

Turning now to Fig. 2 and frontispiece, showing the trial installation of the bucket, it may be noted first of all that while the drawings of Fig. 1 show the jaws made up of riveted pressed steel shapes, the bucket as actually installed has cast steel jaws. At the time the bucket was built this was a decided innovation, but since then cast steel has been used in several clamshells which like the first appear to have been highly successful. Fig. 2 shows the bucket loaded and closed, ready to be swung over the scow and dumped, and the frontispiece is a view showing it open with somewhat more of the dredge boat in sight. As will be observed, the only modifications required on the portion of the dredge in sight is the hose reel on the boom. Inside, of course, there are the unusual installations of an air compressor and receiver.

The problem of handling the hose during operation was a somewhat critical one. It was necessary, of course, that the hose should freely follow the bucket in its descent and as freely and quickly be gotten out of the way in the ascent of the bucket. It was highly desirable also that these operations should be automatic. The solution of the problem which was finally worked out is exceedingly simple. A vertical hose reel with a hollow shaft or axle is carried on bearings on the top member of the boom. From the receiver two lines of iron pipes pass up the boom and terminate in the ends of the hollow shaft. The double hose has connections tapped into the shaft to admit the air to it. In operation the hose is unwound from the reel by direct pull when the dipper is descending. This action, of course, rotates the reel and this rotation winds up a cable attached to a counterweight which slides up and down the boom on an interior track. When the bucket begins to ascend and releases the tension on the hose the counterweight acts by gravity to unwind the counterweight cord which rotates the reel in the reverse direction and winds the hose onto it as fast as it comes up out of the water. As will be seen, both the unwinding and rewinding actions are wholly automatic and require no particular care on the part of the operator.

The bucket illustrated by Fig. 2 and on frontispiece is installed on the dredge "Champion," belonging to The W. H. Beard Dredging Co., 11 William St., New York. At the time the photographs were taken, this dredge was at work digging mud from one of the slips of the Brooklyn Warehouse & Terminal Co., of Brooklyn, N. Y. As previously stated, a double or Siamese hose was used, one barrel of which supplied air to the bottom of the piston and the other to the top of the piston. A pressure of 100 lbs. per sq. in. was worked. The admission of the air to the cylinder and its exhaust were controlled by a three-way cock on each of the two lines of pipe leading to the hose, these cocks being placed in the operator's cabin close to the hand of the dredge operator. At the time the dredge was visited by a member of the staff of this journal, the work of filling a scow was just being completed. The bucket operated quickly and smoothly so far as could be observed and required even less care on the part of the operator, than the ordinary chain-closed bucket. Fig. 2 is a fair illustration of the bucket loads which were being regularly removed. The soft material, of course, favored the bucket, particularly since it was of small size, designed for hard digging.

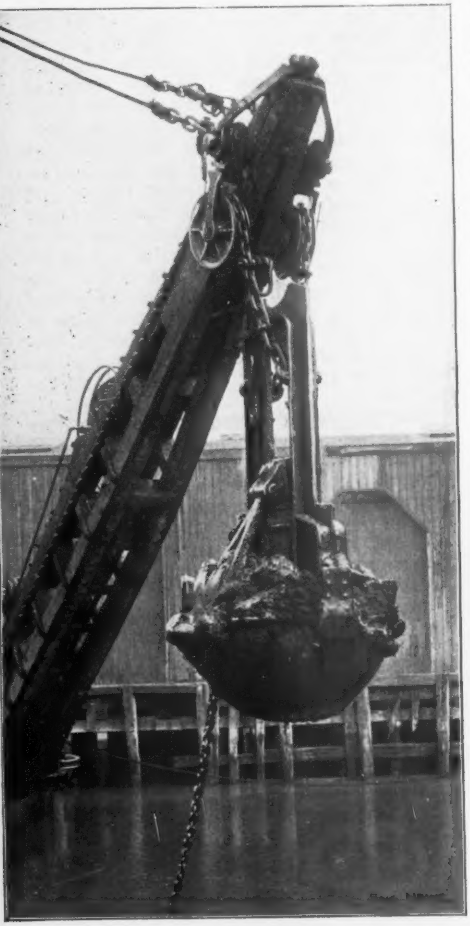


FIG. 2. VIEW OF PNEUMATIC CLAMSHELL DREDGE BUCKET CLOSED WITH LOAD.

Summarized briefly, the main dimensions of the bucket are: Capacity, 3 cu. yds.; extreme height, 15 ft.; extreme width, 76 ins.; diameter of cylinder, 16 ins.; area of piston, 200 sq. ins.; length of stroke, 4 ft.; working pressure of air, 100 lbs. per sq. in.; total pressure on piston, 20,000 lbs.; total weight of reciprocating parts, 9,000 lbs.; total closing force on material, 29,000 lbs.; actual weight of bucket, 24,000 lbs. This bucket was designed for hard digging.

For soft material a larger bucket would be employed and for handling blasted rock the bucket shells would be replaced by grapples.

The advantages claimed for this form of clamshell over chain-closing buckets are: Closing and opening independent of use of frictions; bucket can be lowered into scow well and dumped on the doors without dropping the load; a gain of about 10 ft. in width of cut is made owing to the fact that the chain-closed bucket will fall off in opening; the entire weight of the bucket is on the bottom while closing, and finally the ability to close the bucket at a given depth enables the dressing off of the bottom of the cut at the required depth without over excavation.

The bucket illustrated was designed and has been patented by Mr. W. H. Arnold, engineer and superintendent for The W. H. Beard Dredging Co., of 11 William St., New York. We are indebted to Mr. Arnold for the information from which this description has been prepared.

A New Type Air Compressor.

In a paper read before the Richmond meeting of the American Institute of Mining Engineers, Mr. Henry G. Morris, of Philadelphia, Pa., describes the d'Auria air compressor, which works on the same principle as the d'Auria water pumping engine—that is, without a flywheel. In referring to various types of air compressors, the author quotes that the mechanical efficiency of air compressors ranges from 15 to 60 per cent. and further remarks that any improvements increasing these machines must be of general interest. In describing the d'Auria compressor, he refers to the duplex type, saying: "So far as steam economy is concerned, it may be said to have less limitations than even a crank and flywheel compressor, for the simple reason that, while in the latter the high degree of steam expansion calls for heavier flywheels, heavier crank-shafts, etc., the moving parts in the d'Auria compressor are not in the least affected by the degree of steam expansion, and the machine works equally well with a high, as with a low, expansion.

"Since there is no mechanism of levers, etc., employed to equalize the propelling force and the resistance at every point of the stroke (such as is used, for instance, in a Worthington high-duty pumping engine), the question arises, how perfectly smooth action is attained in the d'Auria compressor, starting at the beginning of the stroke with a high initial pressure of steam against no resistance, and ending the stroke with a propelling force practically *nil*, and resistance at a minimum.

"This result is accomplished by a "hydraulic compensator," which is a cylinder, *A A* Fig. 2, with a plunger, *B*, carried by the same piston rod which connects the steam and the air piston. The ends of the compensator cylinder communicate with each other by means of a loop of pipe, *C C C*, turned into the form of a very rigid bed plate, which adds to the strength of the machine, and preserves, under all conditions, the alignment of the piston rod. This cylinder and pipe are filled with water or any other liquid; and, as there is no loss of liquid beyond that which may leak through the stuffing boxes, they are easily kept full from any source of water supply, through the small pipe and two check valves shown. When the compressor is in action the liquid column contained in the compensator pipe is affected reciprocally, to and fro, by the plunger, and acts in exactly the same manner as a balance wheel in a watch, taking up the excess of energy in the first half, and giving it back with an exceedingly small loss, due to friction, in the second half of the stroke.

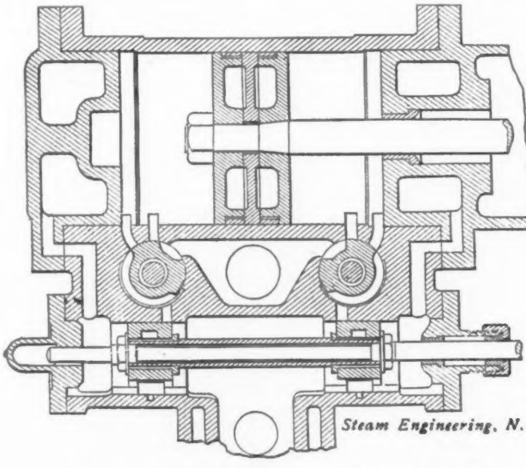


FIG. I. SECTION THROUGH STEAM CYLINDER.

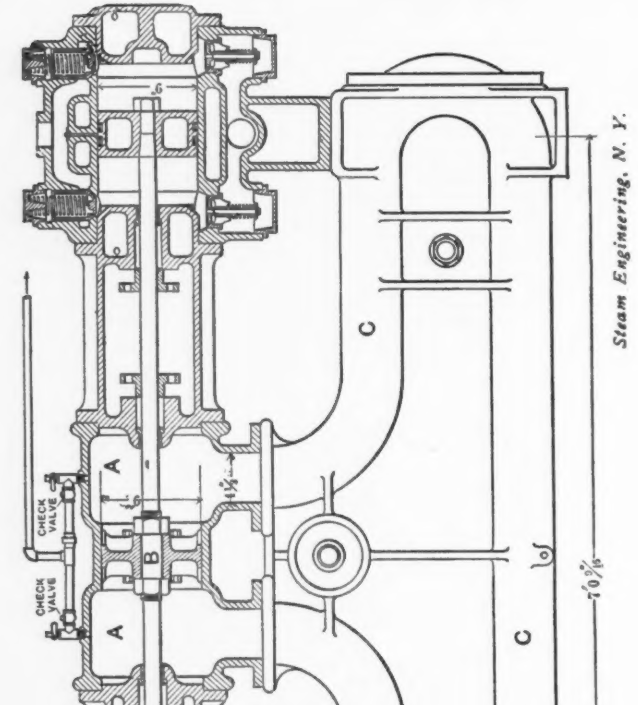


FIG. 2. LONGITUDINAL SECTION THROUGH A D'AURIA DUPLEX AIR COMPRESSOR.

"The action of this compensator is so perfect that the machine is never bolted down to the floor on which it stands, and, under such conditions, can be run at a high rate of speed without vibrations. I have seen an 8 x 9 x 8-inch compressor of this type work suspended in the air from chains, and also run while on rollers, and another of the same size making 340 strokes per minute without being bolted to the floor, and under these conditions, I was able to balance upon it a five-cent piece on edge.

"These compressors have no dead centers. The cycle of their action being limited to the period of one stroke, they are able to start and stop instantly, and, if fitted with a sensitive pressure regulator, will stop completely on a small variation of air pressure, and will start promptly when that pressure falls slightly below the normal.

"It may be asked: What would be the effect of a sudden release of load on the compressor, such as might happen by the breaking of the air pipe? This contingency is met in the compressor, as in the pumping engine of the same type, by a simple and effective device. The exhaust steam in the steam cylinder is cut off by the piston itself about 1.5 inches from the cylinder head; and, from this point on, a considerable amount of steam cushioning is done in the cylinder, stopping the piston, under ordinary conditions, at about ⅜ inch from the cylinder head. Of course, this ⅜-inch clearance is filled up with steam at boiler pressure; which, while it does no harm, does a considerable amount of good by keeping the piston and cylinder head hot when steam is admitted. On the other hand, the compensator plunger has a number of slots, which, in case the stroke becomes longer than normal (that is, if the clearance becomes less than ⅜ inch), overrun the bearing of the plunger, and open a by-pass for the column of water which is pushing the plunger forward. Thus the pressure on both sides is equalized, and the pistons are prevented from striking the cylinder head. Of course, this device comes into play only when the load is suddenly released. Under ordinary conditions—that is, with ⅜ inch of clearance in the steam cylinder—the by-pass in the compensator will not open.

"The machine here illustrated is a small one. In larger sizes, the compressors are made compound, both in air and steam, and fitted with the most approved steam and air valves to insure economy of steam. A d'Auria compressor of 3,000 cubic feet capacity per minute, compound in steam and air, with inter-cooler all complete, weighs about 46,000 pounds, occupies a floor space of 25 x 8 feet, requires no other foundation than a floor to support its weight, and does not need even to be bolted to the floor. A compressor of the crank and flywheel type, capable of doing equally efficient work and of the same capacity, would occupy a floor space of about 56 x 18 feet, and its flywheel alone would weigh 45,000 pounds, the total weight of the machine being probably about 170,000 pounds. Where space is a consideration, the new type offers considerable advantages, occupying only one-fifth as much area as the former type. In weight, it is as one to four, involving much saving in the cost of foundations, which is an important item. Moreover, it can be moved from place to place without any trouble, being, in the full sense of the word, a portable machine. No matter what its size, it will always start and stop promptly by opening or throttling the steam without any dead center."—*Steam Engineering*.

Multiple Stage Air Compression.*

PROF. JOHN H. BARR.

There are many applications in the industrial arts of air under pressure, and the range of applications is constantly increasing.

The pressure of air required varies from an ounce or two per square inch (or even less) for ventilation, to 1,500 or 3,000 lbs. per square inch in power storage or transmission service. For delivery of large volumes of air under very light pressures some form of the fan blower is generally best adapted. The positive rotary blower type is used to advantage for pressures which are high for centrifugal blowers, but low for piston blowers (blowing engines or air compressors). This latter type is usually employed for pressures above a few pounds per square inch.

Of course, the limits within which one of these types can be used are not definite,

*Abstract of a paper read before the Cornell Society of Mechanical Engineers, Dec. 17, 1900, and published in the *Sibley Journal*.

and they overlap more or less. A prominent builder recently constructed two piston type blowing engines of large capacity to deliver air at only 2 pounds per square inch above the atmosphere, though the positive rotary blower is generally adopted for such service. The fan and positive rotary blower frequently compete in such service as blast for forges, etc.

When air is compressed, the work performed upon the air results in heat, and if this heat is not dissipated as rapidly as it is developed the temperature of the mass of air rises. With pressures up to say 15 or 20 pounds above the atmosphere, no serious difficulty or loss is experienced from this heating; hence, in blowing engines, such as are used with Bessemer steel plants, the air cylinder usually has no special provision for cooling the walls. With air compressed to about 40 lbs. above atmosphere, and upwards, the question of cooling the cylinder walls and the air becomes an important one, with any but very small equipments.

In the comparison to be made at this time, the low pressures used for blast, etc., and the very high pressures now being introduced to some extent for transmission and storage of power, will be left out of consideration.

For operating air drills, and for other ordinary mining purposes (except ventilation), the working pressure is usually from 60 to 80 lbs. per square inch. The following remarks are to be understood as applying particularly to pressures not exceeding 100 lbs. above atmosphere.

The primary topics will be single, two, and three stage compression, together with related matters which affect the economy of operation.

To establish a proper base from which to depart, certain elementary matters will be briefly discussed, after calling attention to a few points in the construction of the air compressor cylinders. Automatic valves, may be, and often are, used for both inlet and discharge. They are simple and cheaper than mechanical valves with the mechanism incidental to these latter. Mechanical valves cause less throttling when properly set, because they do not depend upon an excess of pressure to open them. Any considerable throttling during admission results not only in prejudicial resistance, but also in reduction of the capacity of the compressor, as the suction stroke fills the cylinder with air at less than atmospheric pressure. While suction takes place throughout the length of the stroke, discharge only takes place during the latter portion of the stroke, after the air has been compressed to the receiver pressure. (Fig. 1).

On account of the above actions, a moderate excess of pressure to open automatic valves is less objectionable with discharge than with inlet valves. If mechanically operated discharge valves are used, and these be set to open too late, the effect indicated at *a* in Fig. 1 occurs. If, on the other hand, the valves open too early, the effect indicated at *b* takes place.

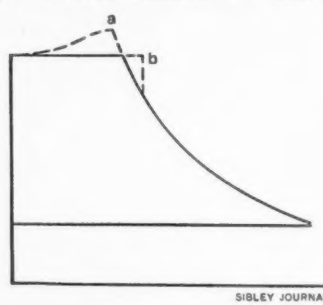


Fig. 1.

If a mechanically operated discharge valve opens when the crank is at *C* (Fig. 2) and closes when the crank is at *C′*, the eccentric moves from *e* to *é* during the period of discharge at one end, and the maximum port opening of the valve corresponds to the distance *a a*. If the discharge valve opens at a point later than one-half stroke, the maximum port opening would be still less. The wrist-plate usually employed in these gears modifies the result somewhat; but for valves opening later than about two-thirds stroke, mechanical valves would require excessive travel to give ample port opening. That is, if air is compressed to above 45 or 50 lbs. per square inch (absolute) from atmospheric pressure, in one cylinder, the discharge valves cannot very well be operated by mechanism. On account of this limitation of mechanical valves, automatic discharge valves are often used in connection with inlet valves operated by mechanism. For a low ratio of compression, and with multiple stage compressors (to be described later), mechanical valves may be, and often are, used.

If the heat is dissipated as rapidly as developed during compression, keeping the air at a constant temperature throughout the operation, the compression is said

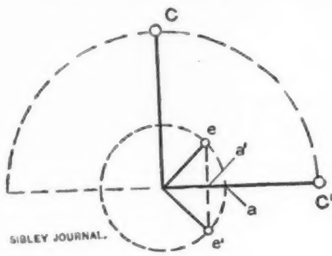


FIG. 2.

to be *isothermal*, and the product of the absolute pressure and the volume of a given weight of air is constant, or $p\ v = a\ constant$. The dotted curve 1-2 (Fig. 3) represents the corresponding variations of pressure and volume. Thus, if one cubic foot of air at 60° F. and atmospheric pressure (14.7 lbs. per square inch) be compressed isothermally to a pressure of 60 lbs. per square inch above the atmosphere (74.7 lbs. per sq. in. absolute), the final volume would be $1 \div \frac{74.7}{14.7} = .197$ cubic feet. The work done in isothermally compressing and in discharging this quantity of air would be 3,420 foot pounds.

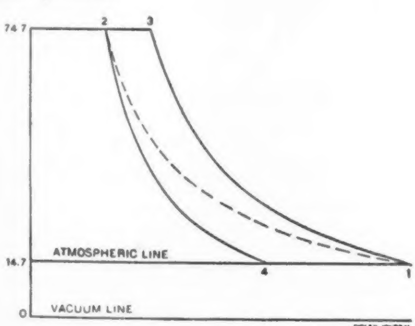


FIG. 3.

If, however, the cubic foot of free air is compressed in an absolutely non-conducting cylinder (without removal of heat due to compression) the law connecting absolute pressure and volume is $p\ v^{1.41} = a\ constant$. This is called *adiabatic* compression and it is represented by the curve 1, 3, Fig. 3.

The rise in temperature of the air due to the heat developed during compression increases the pressure due to a given reduction of volume, or increases the volume due to a given increase of pressure.

One cubic foot of air compressed adiabatically from 14.7 lbs. per square inch (60° F.) to 74.7 lbs. absolute, results in a temperature of about 365° F., and the mass of air will occupy .314 cubic feet. The work required for such compression and the discharge = *4,430 foot lbs.;* or *1,010 foot lbs.* more than with isothermal compression. If, at the end of adiabatic compression, the air could be expanded in a non-conducting cylinder back to the atmospheric pressure, it would do as much work as was required in compressing it (of course, neglecting frictional and incidental losses); just like an ordinary spring.

However, as compressed air is commonly used at a distance from the compressing plant, and as time elapses between compression and such use, the air will cool in the mean time to about the ordinary atmospheric temperature. If the above quantity of air cells from 375° to 60°, while the gauge pressure of 60 lbs. per square inch is maintained, it will contract to about .197 cubic feet. If, after such cooling, the air be expanded in doing work in a non-conducting cylinder, it will reach atmospheric pressure when its volume is only .624 cubic ft., the temperature being about 236° below zero (Fahr.) The work done in such adiabatic expansion is 2,760 foot pounds.

The ideal efficiency, for the case assumed above, with isothermal compression and adiabatic expansion is:

$$E = \frac{2760}{3420} = .81, \text{ or } 81 \text{ per cent.}$$

The ideal efficiency with adiabatic compression, subsequent cooling to 60°, and adiabatic expansion is:

$$E = \frac{2760}{4430} = .625 \text{ or } 62\tfrac{1}{2} \text{ per cent}$$

This shows the desirability of approaching isothermal compression as nearly as possible.

The ideal scheme would be to abstract

the heat as developed during compression, and restore it in reverse order during expansion, so that the temperature will not rise during compression nor fall during expansion. If this were practicable, it would result in a theoretical efficiency of unity, and do away with the inconvenient high temperatures of compression and freezing up during expansion.

Next, the practicable approach to the ideal conditions will be considered. The water jackets on air cylinders keep the cylinder walls moderately cool and facilitate lubrication of the water jacket. The heat taken out through the jacket results in an actual curve of expansion somewhat below the adiabatic, but nearer to this curve than to the isothermal curve in most cases of large compressors at fairly high speeds. The air is heated throughout its mass, and it is a poor conductor of heat; hence the average temperature is not greatly reduced by the jacket.

The full line curve of Fig. 4 indicates a typical compression curve, lying much nearer the adiabatic than the isothermal. The actual compression curve always lies between these two theoretical curves, unless there is considerable leakage back through the inlet valves. In a small cylinder at slow speed the curve should be nearer the isothermal, other things being equal, than with a larger cylinder at higher speed. If a compressor is run very slowly, the compression may approach the isothermal, but this would very greatly reduce the capacity of a machine of given size and cost.

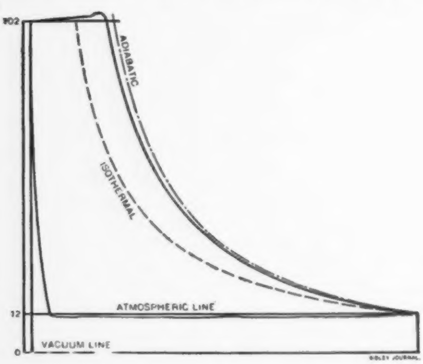


FIG. 4.—DIAGRAM FOR SINGLE STAGE COMPRESSION.

TWO STAGE COMPRESSION. Suppose an air compressor to have a piston displacement of 1 cubic foot per stroke, and that it takes in a cylinderful of air at 14.7 lbs. per square inch and 60° Fahr. and compresses it adiabatically to 30 lbs. per square inch (by gauge). The temperature will rise to about 252°, and the volume will be reduced to .454 cubic feet. If this air is discharged into a receiver in which the pressure of 30 lbs. is maintained, and is there allowed to cool to 60°, the volume will reduce to .33 cubic feet. Next, imagine a smaller compressor, with piston displacement of .33 cubic feet per stroke, to draw in a cylinderful of air, not from the atmosphere, but from this receiver; it will evidently take in a mass of air at 30 lbs. pressure equal to that of the original cubic foot of free air. If the second compressor then compresses the air adiabatically to 60 lbs. (by gauge), the temperature at the end of this operation will be about 175° F., and the volume of this quantity of air will be .202 cubic feet.

The arrangement just indicated is, in principle, a two stage air compressor. The two air cylinders are arranged in a two stage compressor like the two steam cylinders of a compound engine and the intermediate receiver contains a large amount of water-cooled surface, over which the air passes on its way from the first or low pressure cylinder to the second or high pressure cylinder. This intermediate receiver is called an *Intercooler.*

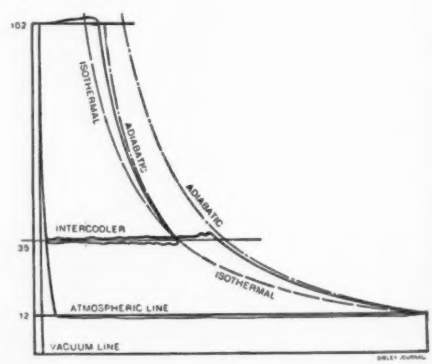


FIG. 5.—DIAGRAM FOR TWO STAGE COMPRESSION.

In this the current of air should always flow in the opposite direction to the current of water, for only with this arrangement can the temperature of the air be reduced approximately to the temperature of the cool entering water.

A typical diagram for a two stage air compressor is represented by Fig. 5. The compression line for the first cylinder lies below the adiabatic, and the pressure during the discharge is represented as slightly higher than the intercooler pressure. The pressure in the second cylinder, during its suction stroke, is slightly lower than the intercooler pressure. This over-lapping of the two diagrams represents a loss of work, the magnitude of

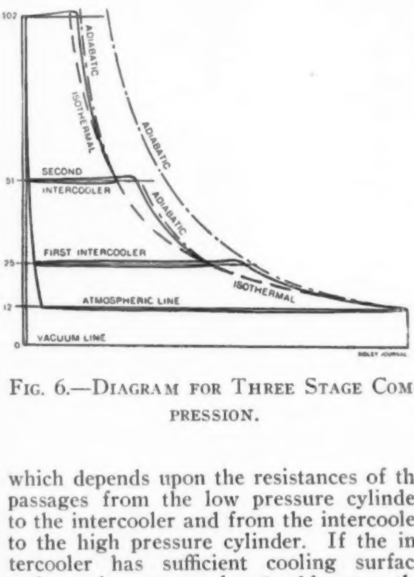


FIG. 6.—DIAGRAM FOR THREE STAGE COMPRESSION.

which depends upon the resistances of the passages from the low pressure cylinder to the intercooler and from the intercooler to the high pressure cylinder. If the intercooler has sufficient cooling surface and an adequate supply of cold water, the air, in passing through it, should be reduced to about the original temperature—that of the outside air. This is often not attained in practice; though it is possible, with water much cooler than the external air, to discharge the air from the intercooler at even a lower temperature than that at which it entered the first cylinder. If the air is cooled to the initial temperature, the compression curve for the second cylinder should be about as shown in Fig. 5; lying below an adiabatic which starts at the intersection of the line of intercooler pressure with the isothermal through the point at which compression begins in the first cylinder.

THREE STAGE COMPRESSION. Three stage compression is effected by three cylinders in series, operating as follows: Air is taken into the first (low pressure) cylinder and compressed to a certain pressure, with corresponding rise of temperature. Then it is transferred to a second (intermediate) cylinder by way of the first intercooler. The compression in the intermediate cylinder carries the pressure to that of the second intercooler, through which the air passes on its way to the third or high pressure cylinder. This last cylinder carries the compression up to the final pressure, and discharges the air into the service receiver. Fig. 6 shows typical three stage diagrams.

The compression could evidently be divided up into as many stages as desired. The larger the number of stages, for a given total ratio of compression, the nearer will be the possible approach to the ideal isothermal compression, and the less will the temperature be increased in each cylinder. A secondary gain from multiple stage compression is due to the reduction of clearance loss over compressors with similar forms of cylinders but fewer stages.

The losses from piston and valve leakage are also less in the higher stage compressors. On the other hand, the loss of power indicated by the overlapping of the diagrams is generally more the larger the number of stages; but this need not be great, with careful design and proper valve setting. There is a practical limit imposed to extension of the number of stages by extra cost, complication, etc. For pressures not exceeding 100 lbs. per square inch, three stages are quite enough; and two stage compression will probably prove nearly as economical, with equally efficient steam ends in the two cases.

Since it is convenient to place one steam cylinder tandem to an air cylinder, three stage compression goes naturally with a triple expansion steam engine; two stage compression with a two cylinder compound; and single stage compression with a simple engine. These combinations are by no means necessary, and many others are entirely feasible; but they may be taken as the most natural arrangements.

The remainder of the article will be taken up with a comparison of the probable performances of—

I. Single Stage Compressor with Simple Engine.

II. Two Stage Compressor with Compound Engine.

III. Three Stage Compressor with Triple Expansion Engine.

The figures for this were taken from the test of a compressor at about 85 per cent. of its full rated capacity. It was designed for a capacity of 4,500 cubic feet of "free air" per minute, measured by the displacement of the low pressure air piston. The delivery pressure was to be 90 lbs. per square inch above the atmosphere, about 102 lbs. absolute, as the atmospheric pressure is a little less than 12 lbs. at the altitude of this plant. The steam pressure is 150 lbs. gauge. The trial showed an economy of 12.34 lbs. of steam per hour, per I. H. P. of the steam cylinders; and a combined mechanical efficiency of engine and compressor equal to 87½ per cent.

For this comparison, the water rate is taken at 12.5 lbs. per I. H. P. of the steam end; the mechanical efficiency as above; the capacity as 4,500 cubic feet of air per minute, as measured by the low pressure piston displacement, and the steam pressure as 150 lbs. gauge.

For two stage compression, with a jacketed, condensing, compound (two cylinder) steam end, the following data is assumed:

Steam pressure = 120 lbs., gauge; water rate = 15 lbs. per I. H. P. per hour; mechanical efficiency of engine and compressor = 85 per cent.*; air pressures and nominal capacity same, as in the preceding.

For the one stage compressor, driven by a simple, jacketed, condensing engine, the data assumed is:

Steam pressure = 80 lbs. gauge; water rate = 19 lbs. per I. H. P. per hour; mechanical efficiency = 82 per cent.*; air pressures and capacity (nominal) as before.

The diagrams, Figs. 4, 5 and 6, represent about what might be accomplished in the air ends of these single stage, two stage and three stage compressors, respectively. Fig. 7 shows Fig. 4 (one stage) superimposed on Fig. 6 (three stage), to give a clearer idea of the gain due to multiple compression. The gain at the air ends of the three stage (Fig. 6) over the two stage (Fig. 5) is very much less than that of the two stage (Fig. 5) over the one stage (Fig. 4). This will be seen from inspection of the first column of the following table, which gives the general results of the computations. The last column of this table gives the calculated coal

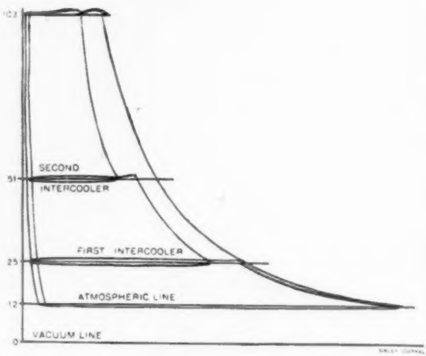


FIG. 7—COMBINATION OF SINGLE AND THREE STAGE COMPRESSION.

consumption, based upon an assumed evaporation of eight pounds of steam per pound of coal burned.

The results are obtained as follows:

The horse power of air cylinders is computed on the basis of adiabatic compression in each cylinder, and cooling to the isothermal (the original temperature) in each intercooler; with some modifications to allow for deviation of compression curves from the adiabatics, for "overlapping" of diagrams, clearance, etc. The horse power of the steam ends is derived from that of the air ends by dividing the latter quantities by the mechanical efficiencies assigned for the respective cases. The steam used per hour for each case is the steam horse power multiplied by the corresponding water rate; and the coal per hour is this last figure divided by eight. Of course, the results are rough

*The better distribution of pressures on the various bearings is the basis for assumption of the higher efficiency with the greater number of cranks.

and only give what is considered as probable general results.

SUMMARY.

Type.	Horse Power.		Steam per hr. (lbs.)	Coal per hr. (bls.)
	Air.	Steam.		
One stage..	700	850	16,150	2.020
Two stage.	600	705	10.575	1,322
Three stage	580	663	8,290	1,036

An inspection of this table shows a decided gain by two stage compression over one stage compression, through reduction of the air horse power. The gain attributed to the three stage triple expansion system over the two stage compound, appears to be due almost wholly to the superior economy of the triple expansion steam end. This would not necessarily apply, however, when compressing to higher pressures.

Patent Portable Punch.

The cut herewith shows in its improved form a Portable Pneumatic Punch which was originally designed by the superintendent of a prominent ship-building firm for the use of the concern in building two torpedo boat destroyers for the United States Government.

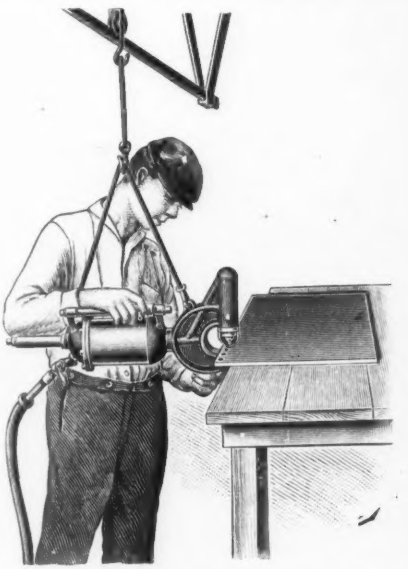
The original tool constructed for this purpose is still in use, and actually did ninety per cent. of the work on the two boats for which it was intended. Of course, there were some improvements suggesting themselves, and these have been embodied in the Punch as now constructed.

A number of these tools have already been installed by leading ship-building firms, railroad shops, etc., and we understand have given the most unqualified satisfaction.

There is evidently a bright future for tools of this class, as by their use one man or boy can do quite as much work as can be done by the gang of men required to accomplish work on the power punch by the method now in common use. Indeed, we believe that the advantage on the side of the Pneumatic tool will be found even greater, as it is easier for one man to guide the tool to the exact spot to be punched than for a number of men to move heavy work just the right distance. For the same reason, no doubt, the work will be done more accurately.

Another very important advantage will be the great saving in space made possible by having the work stationary, as it requires a space double the length of a sheet or beam to punch it on a power machine.

But perhaps the chief gain in the use of tools of this class will be on work that either cannot be reached by the power punch at all, or else that requires to be



PATENT PORTABLE PUNCH.

taken down and carried to punch and then put in place again. On all work done on board ship, in erection, and on work in the field, etc., and for man-hole work on boilers, as well as uptakes, tanks, stacks, etc., the portable punch will be found to take a place which has heretofore been filled in a variety of ways, all more or less unsatisfactory, slow and expensive.

The Punch here illustrated is built in four sizes, the smallest, or size O, weigh-

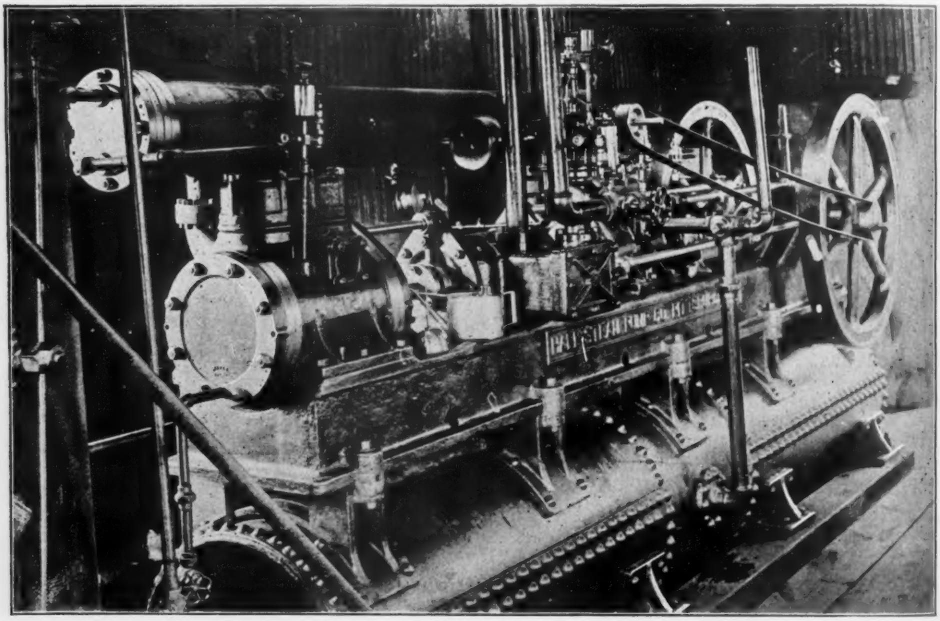
ing 28 lbs., is adapted to work up to 3-16 inches; size 1, shown in cut, weighs 145 lbs., and will punch up to ⅜ inches; sizes 2 and 3 are adapted for punching ½ in. and ¾ in. plates respectively.

In construction the tool is quite simple, and this gives it great durability; the chief distinctive feature being a hollow piston containing oil, within a prolongation of which a stationary tube is adapted to telescope—the oil being thereby forced into and through said tube and thence upon the plunger, where it exerts accumulated pressure. The air which drives the piston during the stroke is utilized to drive it back for another, being finally expelled through the exhaust during the next succeeding stroke. This, as will be apparent, effects an important saving in the amount of air used.

Mr. S. S. Caskey, the inventor of this Punch, is already known as the inventor of a successful pneumatic riveter. The "Caskey" Pneumatic Punch is built by F. F. Slocomb & Co., Wilmington, Del., from whom any further details may be had.

An Air Compressor Plant for Field Riveting.

A compact arrangement of air compressor, receiver, boiler and steam pump for field pneumatic riveting, drilling, caulking, reaming, etc., in general bridge and structural work has been designed by Mr. W. A. Cline, superintendent of erection of the Keystone branch of the American Bridge Company. It was first used in the erection of the open-hearth furnaces of the Duquesne Steel Works of the Carnegie Steel Company, and is now in service at the Union Railroad Company's Rankin bridge across the Monongahela River. The apparatus was designed for convenience of transportation and economy of space, to be quickly set up and put in operation for management by an engineman of ordinary skill.

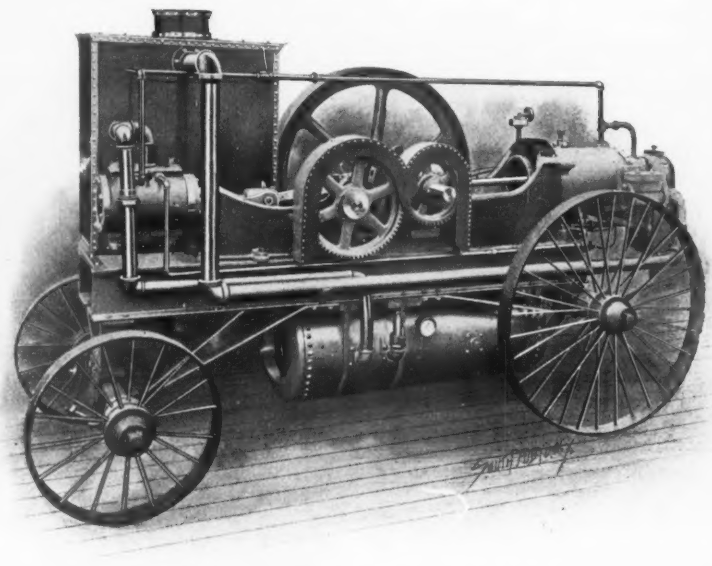


AN AIR COMPRESSOR PLANT FOR BRIDGE WORK

The bed consists of two 12 x 12-inch

longitudinal sills 20 feet long, which are braced and bolted together 30 inches apart in the clear. Between and above them a 30-inch horizontal receiver 14 feet long is mounted on riveted cast lugs and serves as a base on which there are saddle pieces carrying a standard air compressor. A vertical boiler is seated on the end of the sills and between it and the compressor there is a pump with 5-inch steam cylinder, 3-inch water cylinder, and 7-inch stroke to circulate water through the jackets of the cylinders and inter-cooler. The outside dimensions of the complete apparatus are 20 x 4 feet x 12 feet high to the top of the boiler, but the compressor and receiver alone occupy a space only 4 feet wide, 16 feet long and 7½ feet high. The tandem two-stage compressor has 10-inch steam and low-pressure air cylinders and a 6-inch high pressure air cylinder, all with 14-inch stroke. There is a copper-tube inter-cooler between the air cylinders, both of which are jacketed for the circulation of water.

With a boiler pressure of 70 pounds, the air pressure in the receiver is maintained at 105 pounds with the compressor running at a speed of 50 to 60 revolutions per minute, and is controlled by a governor and automatic pressure regulator. Under test an air pressure of 140 pounds was developed with 95 pounds steam pressure and the receiver was subjected to a cold-water pressure of 300 pounds. The receiver is fitted with a pressure gauge indicating up to 180 pounds and a pop safety valve set at 120 pounds. The diameters in inches of the different pipe connections are: Compressor, steam, 2; exhaust, 2½; air inlet, 3; air outlet to receiver, 2; outlet from receiver, 2½; water jacket, inlet and outlet, ¾. Pump steam, ½; exhaust, 1; suction, 2; delivery, 1½. The view shows the compressor and receiver only, as they are now installed and operating six pneumatic riveting hammers, furnishing blast to the rivet-heating forges and drilling 2-inch holes in 1½-inch material with a Monitor air drill. The compressor and air receiver were made by the Hall Steam Pump Company, of Pittsburg, and assembled after plans furnished by the Keystone Bridge Works. The data concerning the apparatus were furnished by Mr. J. K. Lyons, engineer of Keystone branch of the American Bridge Company.—*Engineering Record.*



A PORTABLE AIR COMPRESSING PLANT.

A Portable Air Compressor.

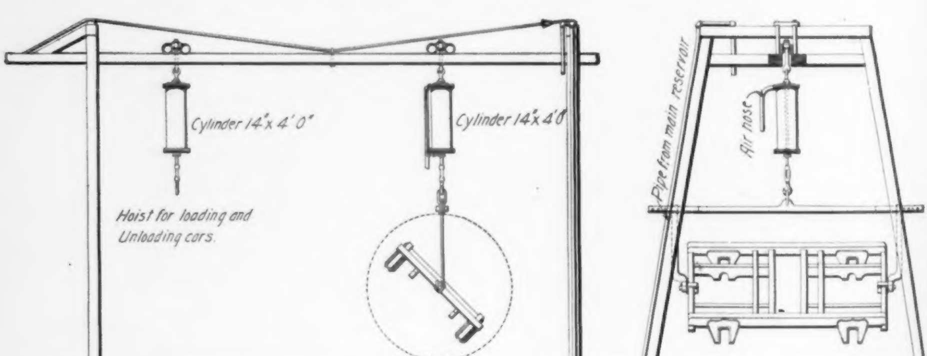
A very interesting portable plant is shown in the accompanying illustration. The actual work for which this was designed is in connection with drills, riveters and other pneumatic appliances on one of the sections of the great Rapid Transit Underground Railway now building in New York City.

The illustration affords a very clear idea of the construction of this plant, which is light, compact, and entirely self-contained. The truck is made of channel irons supported on four solid steel spoke wheels, the front wheels being swiveled as in an ordinary wagon to permit the equipment to be drawn about the streets. It is seen that at the rear end is an oil engine, while in the front is the compressor. These are geared together so as to give the proper speed relation. Directly underneath is the steel receiver for holding the compressed air while to the left of the compressor is a special water cooling arrangement.

The engine is of the well known Hornsby-Akroyd type operated by oil, and when run at maximum speed, delivers 13 H. P. The normal speed is 235 revolutions per minute, and the gearing is arranged to give a compressor speed of 150 revolutions. Under normal conditions the compressor which is a double acting Ingersoll-Sergeant, Class E type, has a capacity of 70 cubic feet of free air per minute which it compresses to 100 pounds per square inch. The cylinder of this compressor is 8 inches by 8 inches, and is water-jacketed throughout, as is also the cylinder of the oil engine.

For this purpose water is circulated through a special cooler and then through the cylinders by means of a small reciprocating pump operated by an eccentric keyed to the engine shaft. Forty gallons are necessary to maintain the proper working temperature for the outfit, and this is kept circulating continually by the pump. The cooler is found to work very satisfactorily. Water enters the top of the device after having passed through the cylinders and is allowed to run back and forth over wooden slats which are especially arranged to expose the water to a stronger current of air. To create this current, the exhaust from the engine is allowed to blow up through a chimney on top of the cooler much in the same way as the exhaust of a locomotive operates.

The equipment complete weighs between 7,000 and 8,000 pounds and is easily handled by two horses. It is driven up to the place where it is to be used and the wheels blocked with a special arrangement, after which the oil engine is started up and tubes attached to the receiver from which the air under pressure is drawn. Ordinary kerosene or inferior grades of petroleum or crude oil are used in the engine and it has been found that the equipment works very satisfactorily with practically no attention, and that the full output of the compressor is obtained at a very low cost of operation. This equipment was built by the De La Vergne Refrigerating Co., of New York, the compressor being furnished by The Ingersoll-Sergeant Drill Co., also of New York.



A CRANE FOR REPAIRING CAR TRUCKS.

Hoist for Repairing Passenger Car Trucks.

LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

The weight of truck frames of passenger equipment renders them exceedingly awkward to handle in the shop and they are built up of so many parts as to necessitate considerable work in overhauling. The accompanying engraving illustrates an air crane arrangement used at Cleveland at the shops of the Lake Shore & Michigan Southern, the drawing of which was received through the courtesy of Mr. W. H. Marshall, Superintendent of Motive Power. The device has been in use for several years and it has proved to be a valuable one which may be used to advantage elsewhere.

A frame work carries a trolley bar spanning two tracks and supports two trolleys, to each of which a 14 by 48-inch air cylinder is hung. The one at the left is used for loading and unloading cars, and the one at the right is fitted with a cross bar and slings, the lower ends of which are provided with swiveled clamps for supporting truck frames. These are raised by the air pressure and they may be tipped for convenience in getting at the bolts and other work on the under side of the frames. Both cylinders may be used for this work if desired. The arrangement is completed by the air hose connections and the necessary valves.

Diagram for Calculating Compressed Air Pressure.

The graphic table herewith presented is intended to facilitate calculations in power transmission by compressed air. Any problem within the limits of the table can be solved by a glance without reference to the usual intricate formulas. The table is spaced on a logarithmic scale, thus giving, at the same time, large range of values with accuracy in smaller quantities. Horizontal lines show loss of pressure in pounds per 100 feet of pipe, and vertical lines show cubic feet of free air per minute. A single example will suffice to show the manner of using the table:

Example: It is required to operate ten drills using 1,000 feet free air per minute at a distance of 6,000 feet from the compressor. The air is transmitted through 5" pipe. What additional pressure will be required at the compressor to give 75 pounds terminal gauge pressure?

Referring to the diagram, take the vertical line denoting 1,000 cubic feet free air per minute, follow it up to intersection with curved line representing 5" pipe; note the horizontal line at the same intersection which denotes .10 pound, which is the additional pressure required for 100 feet of pipe; whence

$\frac{.10\times600}{100}=6$ pounds, and 75 pounds $+$ 6 pounds $=$ 81 pounds, the gauge pressure required at the compressor.

If the air is to be transmitted through 4" pipe, we have:

$\frac{.32\times6000}{100}=19.2$ pounds, and 75 pounds $\times$ 19.2 pounds $=$ 94.2 pounds, the compressor gauge pressure required.—*Mining and Scientific Press.*

The Influence of Portable Tools on Workshop Practice.

For more than a generation we have had at our bidding a faithful servant, who performed certain heavy tasks faithfully and well. No one suspected until a very few years ago that this servant was able and willing to perform a multitude of other tasks of a wholly different sort, and with a neatness and promptness heretofore unknown.

This useful servant is compressed air. We kept him working in tunnels and mines and quarries, churning down holes to be loaded with explosives, and he set the brakes on our passenger trains. No one thought of taking him into the machine shop and the foundry, the woodworking mill and the stone-cutter's yard and setting him to work there to relieve human muscle.

A dozen years or so ago, however, it was found that he could be harnessed to a light hand tool and made to drive it back and forth a thousand or more times in a minute. Similar tools to give a rotary motion followed close after, and our old servant was fairly established in his new career.

At the same time, as most of our readers are aware, a great variety of other new applications of compressed air have

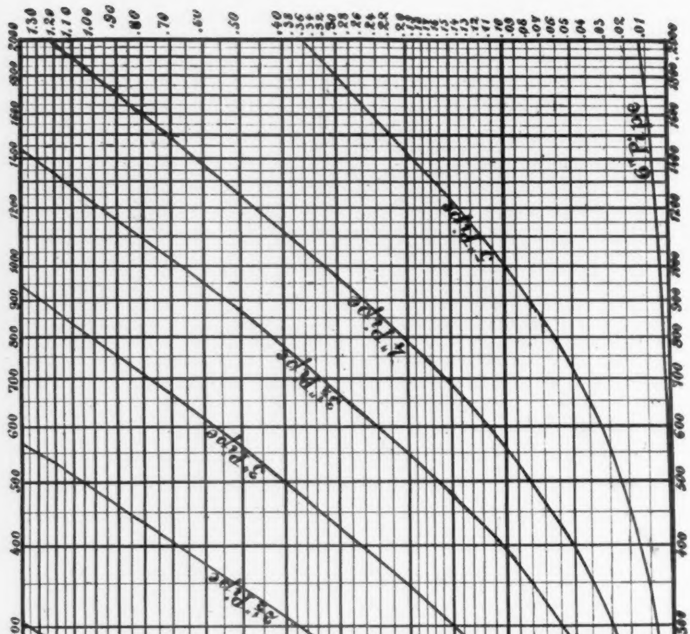


DIAGRAM FOR CALCULATING COMPRESSED AIR PRESSURE.

been made; but it is doubtful whether any of them compare in industrial importance with its application to portable tools. A large number of these have now been designed and put upon the market, applicable to a very wide range of uses in special industries, and additions to the list are continually being made.

So far, the most important application of these tools has been to displace, or rather to increase the efficiency of, the hand workman. The file and the chisel, the chipping hammer and the caulking tool, propelled by the blows of the hand sledge, are fast disappearing. In their place is heard the buzz of the pneumatic tool. These uses of compressed air are now familiar, and the matter to which we want to call attention is the further changes in workshop practice which seem likely to be brought about, and indeed are already appearing through the efficiency of these new portable tools.

In any manufacturing process, a question which must always be decided is whether the work shall be taken to the tool or the tool to the work. In the early days of manufacturing industry, when the use of machinery was in its infancy, and a factory was only an assemblage of workmen using hand tools, and aiding each other through division of labor, it was common practice to take the tools to the work. With the development of automatic machine tools to replace the hand tool in almost every process, it became necessary to reverse this system and take the work to the tool. Where the pieces to be worked were of large size and weight, this involved much difficulty, and in the olden times large expenditure of human muscle. It is not so long ago since the only equipment of a machine shop or foundry to handle the materials worked upon consisted of block and tackle or clumsy jib cranes, all worked by "main strength." We need hardly say that compressed air and electricity have changed all that. No modern manufactory doing heavy work is equipped for economical production without an outfit of pneumatic hoists and electric cranes, and this is often supplemented with something in the way of a general conveying system, perhaps in the shape of a shop railway operated by electric power.

These devices perform admirable service, and in many cases their use will be permanent. There are other cases, however, where the development of portable tools is likely to cause a return to the former practice. Instead of taking the work to the tool, it will again become common to take the tool to the work. It will be of interest to note some practical illustrations. One which has already become common and is familiar to most of our readers is the operation of riveting. The first power riveters (some of them still in use for places where a deep gap is essential) were ponderous machines, fixed in place, operated by hydraulic or steam pressure, and the work was, of course, brought to them. For every rivet driven, the heavy plate or boiler or whatever was in hand had to be swung to just the right position for the jaws to close down on the hot rivet. As we have remarked, such machines are still in use for work where a deep gap between the jaws of a machine is essential; but for all ordinary work, the light portable pneumatic riveter which is taken to the work can be operated much more rapidly.

An illustration of more recent date occurs in foundry practice. The foundry is the department of machine construction where hand tools and hand work have longest retained their sway. It is only within the past dozen years that machine molding has come to have an important place in foundry work. With machine molding, however, an important change in the foundry system became necessary. The molding machine is a fixed machine, and the work had to be brought to it. That is to say, the machine had to be kept supplied with empty flasks and sand, and the completed flasks had to be carried off to the pouring floor. Thus some system of mechanical conveying frequently became a necessity to supplement the molding machine and enable it to work up to its capacity. These conveying systems often cost more to build and to operate than the molding machine itself. As those of our readers familiar with foundry work are aware, the chief work done by a molding machine is to ram or pack the sand in the flask. Recently portable pneumatic rammers have been developed, which in many places are claimed to do as good and more rapid work than the fixed molding machines. The tool is taken to the work again instead of the work to the tool. The flask is filled and rammed on the pouring floor, just as was done in the foundry before the introduc-

tion of molding machines, and the conveying of sand and flasks from the pouring floor to the machine and back to the floor again is no longer necessary.

Of course, there are classes of work where the fixed molding machine will still prove superior. There are others where the portable rammer will be a far more economical tool. It is the business of the managers to select the equipment best suited to their special conditions.

In general it will be evident that the portable tools will be of undoubted superiority on large and heavy work. The fixed machines will be equally certain of preference in shops where small repetition work is the chief output. The changes in workshop practice which we are discussing, therefore, will not affect the manufacturer of small articles. The workshops where such changes will take place are those where huge and heavy things are made—the boiler shops, the bridge works, the ship yards, the builders of heavy machinery. Here portable tools are already found in large numbers, and new fields for their profitable employment are all the time appearing.

We have thus far spoken chiefly of compressed air in connection with the development of portable tools, although electric power has also played some part in this work. The electric motor has the very considerable advantage for use in a portable tool that its supply of energy is derived from a flexible cable instead of a flexible hose, and it can be used, therefore, with a longer range from a fixed point than with less expense and difficulty in power distribution than compressed air. This advantage of electricity, however, is more than offset by the fact that electricity requires considerably more weight in the tool itself to give an equal blow or an equal torque with the compressed air tool, and this seriously interferes with the portability and rapid use of the electric tool. Besides this, small sizes of electric motors are so inefficient in use of current as to heat rapidly and become inconvenient to handle. Nevertheless, for special purposes, electricity may at times be the superior; and its possibilities should not be overlooked by designers and users of portable tools.—*Engineering News.*

Efficiency of Rock Drills.

Let me know upon what is based the efficiency of rock drills. Has there been any method devised for testing the force of the blow, the pull and the twisting moment? T. G. S.

Berkeley, Cal.

In response to the above, an expert on the subject says:

I am not aware of any systematic tests performed to precisely determine the exact strength of the blow, the back pull and the twisting moment. In fact, I do not believe that deep scientific research in this direction would be justified, or rather would lead to anything like absolute and useful rules, for the following reasons:

A rock drill—I mean the most common variety, i. e., the percussion rock drill driven by compressed air—is essentially and admittedly a machine of low mechanical efficiency, if this term implies that the amount of work done by the compressed air in the cylinder of the rock drill is only a small percentage of the work expended in operating the compressor.

Experience shows that a successful rock drill must fulfill a number of requisites, among which the mechanical efficiency is not by any means the most important. The methods which would naturally suggest themselves to improve this efficiency would, at the same time, make the machine unpractical, and the best that can be done in this direction is apparently to eliminate all hindrances to the delivery of the blow from the piston to the rock, i. e., to avoid cushioning on the fore end of the piston, and to maintain the full pressure of air on its back end as long as practicable. Quick action is also a desirable feature, and means wide and short passages between the valve chest and the cylinder at a possible increase in the air consumption of the machine.

But while these requirements may be said to always exist, they must be satisfied to various degrees, according to the nature of the ground. The true value of a rock drill is ultimately gauged at its capacity for making a rapid advance in a given sort of ground, and this involves not only the percussive power of the machine, but also its adaptation to mudding, i. e., to keeping the hole free from obstructions.

The result is that an efficient machine, i. e., one designed to deliver a powerful blow on hard rock, may not do comparatively as good work in soft or seamy ground, while a test of its percussive capacity would have led to declare it efficient.

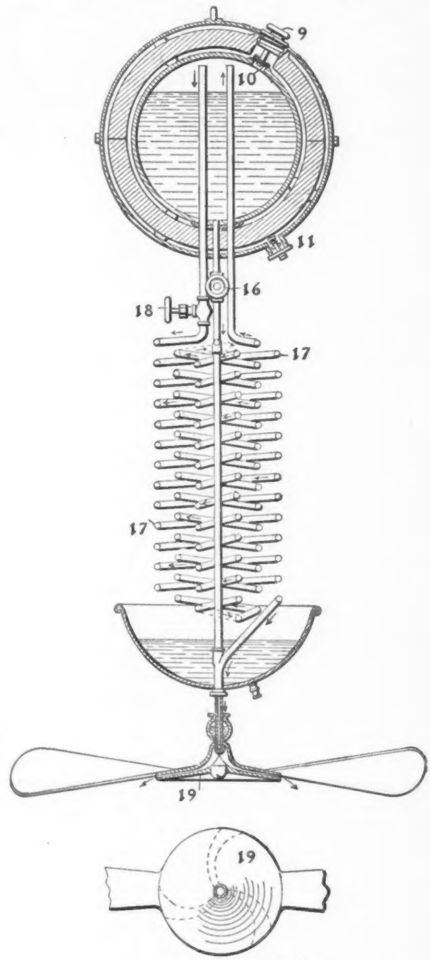
The pull and the twisting moment can be estimated from the air pressure, the size of the piston and the pitch of the rifle bar, but the result of this computation may be of little use to determine the actual working value of a rock drill.

In my opinion, precise methods of investigation, which have been so fruitful of valuable results in the case of steam and internal combustion engines, would not be warranted in the case of rock drills. —*Mining and Scientific Press.*

A Liquid Air Motor.

The cut, from a recent United States patent, shows the essential features of an interesting device in which it is proposed to employ liquid air both for the development of power and for its refrigerative effect. The inventor is Mr. O. P. Ostergren, the inventor of an air-liquefying apparatus already in operation in this city.

At the top is seen the receptacle for the liquid air. This receptacle or reservoir consists of an inner and an outer shell with a considerable space between them in which is some suitable heat-insulating material, such as porous carbon, which is supported from contact with either the inner or the outer shell. The liquid air is poured into the reservoir through the opening 9-10, the inner opening 10 being closed by an outwardly opening check valve. As vaporization occurs in the inner reservoir, while air is not being used for power, it passes out through the check valve, along the space next to the inner shell and circulates through the porous insulating material, assisting in the maintenance of the low temperature and escaping by the safety valve 11, which is set to blow off at a pressure of two or three pounds. This pressure is the limit of the working pressure of the apparatus, and when valve 18 is opened the air, instead of passing out through the check valve and the safety valve, will pass down through the outer helical coil of pipe 17, where its temperature will be raised more or less, thus increasing its volume. From coil 17 the air passes into the central pipe at the bottom and then to the air-turbine 19, escaping through the curved passages



A LIQUID-AIR MOTOR.

indicated and causing the fan blades to revolve, the air mingling with the atmosphere of the apartment and reducing its temperature. As more air is required to drive the fan, valve 16 is opened and the liquid air passes down through the coil of smallest diameter and up through the

next larger coil and through the vertical pipe to the air space at the top of the air reservoir, being by this transit entirely vaporized. From the air space of the reservoir it of course passes down the other pipe to the fan. It will be seen that by this apparatus the entire cooling effect of the air, in converting it from the liquid form to air of normal temperature, is used in the apartment, while sufficient power is developed to drive the fan. The valves 16 and 18 are of the needle type, giving a minute opening easily regulated.

Notes.

The Sullivan Machinery Co., Claremont, N. H., manufacturers of Sullivan core drills, channelers, gadders, coal mining machines, etc., have increased their capital stock from $600,000 to $800,000.

On the recommendation of the Franklin Institute, the silver medal and diploma was awarded by the National Export Exposition to the International Correspondence Schools, Scranton, Pa., for a unique, thorough and comprehensive system of technical education by correspondence.

The Pittsburg Pneumatic Crane Co. has been incorporated under the laws of Pennsylvania to manufacture pneumatic cranes of all descriptions. W. S. Hasley, George Morman, Charles Murphy, Edward Schreiner and Albert J. Loeffler are the incorporators.

The Pneumatic Scale Company have organized at Kittery, Maine, for the purpose of manufacturing electrical, mechanical and pneumatic machinery, novelties, etc., with $1,000,000 capital stock, of which nothing is paid in. The officers are: President, Joel F. Shepard of Braintree, Mass.; treasurer, W. H. Doble of Quincy. Certificate approved May 6, 1901.

—Fraser & Chalmers, Limited, 43, Threadneedle Street, London, and F. L. Whitmore, Howrah Lodge, Belvedere, Kent.—Provide an apparatus which will regulate with certainty the speed of the compressing engine by the varying pressure of the compressed gas or air, or in pumping engines by the varying head of liquid to be pumped.

The Merrill Pneumatic Pump Company, of Bound Brook, N. J., has issued some striking booklets, excellent specimens of the art preservative, in which is presented interesting data embodying recent important improvements and new designs for pumping liquids from all sources and for all duties. The company has its New York office in the Washington Life Building, 141 Broadway.

As noted in our columns some time ago, John B. Smith & Sons, of Toronto, Canada, are using compressed air very successfully in handling loads of lumber and timbers. A visitor there has seen the company's team go to a load which was ready to put on to the wagon, and from the time the wagon stopped opposite the load until the lumber, (weighing nearly four tons) was in the wagon, only forty-five seconds elapsed.

The contract for a complete Central Air Compressing Plant was awarded the McKiernan Drill Co., by Messrs. Shanahan, Woolfolk & Co., South Framingham, Mass., who have secured a large contract from the Metropolitan Water Board, Boston, Mass., for an aqueduct consisting of two tunnels, etc., etc.

The amount of the contract secured by the McKiernan Drill Co. is in the neighborhood of $25,000.

The Markham Air Rifle Co., of Plymouth, Mich., are offering a new air rifle for which they claim especial merit as against competitors. The stock is made of black walnut with the metal portions of the rifle well finished, and measures 34 inches over all. It is a little heavier than other rifles made by this company. The barrel can be instantly removed for shooting regular air gun darts or for cleaning. This rifle also shoots ordinary B B shot. Each rifle is packed in a box 4½ inches wide by 14 inches long, the rifle being taken apart for packing.

William H. Meyers, of Sturgis, Ky., has recently patented a pneumatic cotton picker which he will manufacture in Louisville. Mr. Meyers has sold an interest in his invention to New York capitalists and he expects shortly to dispose of another interest to Texas persons. When in operation the machine is fastened to an ordinary farm wagon. It

picks the cotton from three rows at a time and as fast as the horses can walk. The cotton is dumped in a wagon which follows, to be carted from the field. It is operated by a small gasoline engine.

The engraving explains the Knapsack Paint Can pretty well. A tube runs from the reservoir in the knapsack down through the paint brush handle, the reservoir being placed high enough to force the paint by gravity into the brush. Valves

are provided for regulating the flow of the paint. For use on ceilings a small rubber bulb may be used to increase the pressure inside the reservoir until the paint is forced to a higher level and feeds the brush as before. Nelson Stow, Binghamton, N. Y., invented the apparatus.—*Master Painter.*

What will no doubt prove a most interesting feature of the Baldwin Locomotive Works' exhibit at the Pan-American Exposition at Buffalo is a large locomotive which will be jacked up and operated by compressed air so that visitors can see just how the engine makes "the wheels go 'round" when the locomotive is running on the track. This locomotive is to be supplied with compressed air from two No. 3 Pedrick & Ayer Compound Automatic Belt Air Compressors, which will pump the air into the main boiler of the locomotive and so furnish the motive power.

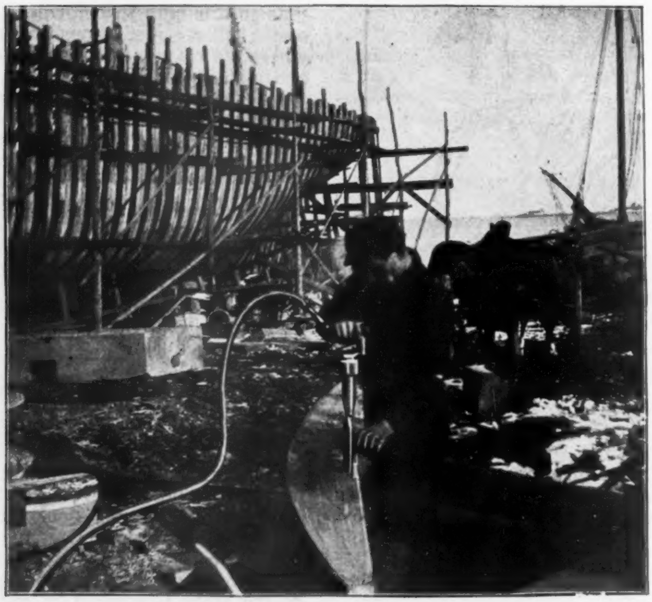
The Pedrick & Ayer Co., manufacturers of the compressors to be used, have offices at 85, 87, 89 Liberty Street, New York City.

At a recent meeting of the St. Louis Railway Club Mr. Gohen, of the Big Four, spoke of a good arrangement used by that road to protect car cleaners from danger of infection by dust. "We are cleaning cars with air, and we are granting immunity to our men who clean them, from infection by this dust. It is a very simple operation, and I cannot explain its details to this club just now, but we have at our Shelby street shops in Indianapolis, where we clean a great many cars by air, and also in Cincinnati, an attachment put upon the end of this air blowing machine, which carries all the dust that accumulates through the blowing out of the car, outside of the car into the air, through the means of a piece of hose—engine tank hose, I guess. It is about the size of engine tank hose. That is attached to our blower in such a way as to carry all the dust and everything out into the air, so that the classes who in reality should be guaranteed from immunity are those people on the outside."

In an electric winding engine, made by Schmidt, Kranz und Co., of Nordhausen, in the Prussian province of Saxony, the electromotors are keyed directly on the drum shaft, so that there is no necessity for spur or other gear; and a strong hollow cast-iron frame, on which the field magnets are placed, carries two long bearings (provided with ring lubrication) in which revolves the single shaft. The ordinary brake is worked by compressed air or water under pressure, and the emergency brake by the release of a weight, effected automatically by electricity or by the engineman with a pedal. The engine, which can be regulated for winding speeds of 30 mm. (1 3-16 in.) to 7 m. (23 ft.) per second, is fitted with a retarding appliance two lift indicators and an arrangement for eventually putting on the emergency brake. A pneumatic or hydraulic contrivance is added for taking up and again giving out the *vis viva* of the cage when coming down on the keps; and drawing up the cage a little above the

keps before lowering is rendered unnecessary, so that an engine of considerably less power than usual is sufficient.

One of the latest uses to which pneumatic tools have been applied is chiseling and gouging by means of properly formed tools used in connection with a pneumatic hammer. We show in the accompanying illustration the "Little Giant" Pneumatic Hammer, manufactured by The Standard Pneumatic Tool Co., of Chicago and New York, at work in a shipyard, mortising. The hammer strikes a series of very rapid blows upon the end of the chisel inserted in the hammer, and the chisel is thereby driven rapidly into the timber desired to be mortised, or otherwise treated. The work is done much more rapidly and with greater ease to the operator than by hand when using a mallet and hand chisel. For this class of work and all large framing where timbers are used, these tools will be found of inestimable value.



USE OF THE PNEUMATIC HAMMER IN SHIP BUILDING.

The Curtis & Company Manufacturing Company, St. Louis, Mo., manufacturers of pneumatic appliances for the machine shop, have brought out a pneumatic elevator for manufacturing plants. This is especially adapted to locations removed from the source of power, as no belt connections are necessary and there is not the danger of freezing experienced with hydraulic elevators.

The elevators can be used between two positive stops only and are not adapted to stop at intermediate floors. They are made in sizes having capacities from 1,200 to 10,000 pounds, and with a lift up to 40 feet. The speed is in full control of the operator. As the air required is simply the volume necessary to fill the air cylinder when the cage ascends, a large reservoir and a small compressor are economical for elevator use.

To insure against accident, spring buffers are furnished for the upper level and there is a special rope lock, so that the cage can be locked at either floor required, making it impossible for a thoughtless person to cause an accident by starting the elevator when it is being loaded or unloaded.

According to the *American Engineer,* a new system for utilizing the exhaust steam from the air pump of a locomotive for the purpose of heating passenger trains is being applied to locomotives on the Maine Central Railroad, and is also used on other New England roads. The system is simple, consisting of a three-way cock attached to the exhaust pipe immediately in front of the pump and operated by a lever to which is attached a reach rod that passes into the cab to the engineer. Of the two pipes issuing from the three-way cock, one is connected by the ordinary exhaust pipe to a jacketed reservoir about 40 inches long and 20 inches diameter, hung beneath the cab. The second exhaust pipe is connected with the smokestack. The outlet pipe to this reservoir is at the rear end near the bottom and is connected to the train steam pipe by means of a flexible hose connection. The question of back pressure and its interference with the action of the air pump does not appear to be serious. With the common pressure of 200 pounds in the boiler the pump can be easily operated against the back pressure of 20 or 30 pounds usuallly required, and it is stated that the Maine Central have carried 65 pounds back pressure when needed.

In February last proposals were received by Mason M. Patrick, captain of engineers, U. S. A., of the Mississippi River Commission, for the installation of six refrigerating plants, complete, one each on the five government steam tenders, Sachem, Choctaw, Wynoka, Nokomis and Leota, and one on the steam dredge Iota. It was specified that each plant should have a capacity for making at least half a ton of ice per twenty-four hours and for cooling a storage room already constructed 13 x 6½ feet by 7 feet high in the clear. The necessary amount of brine piping was to be furnished and erected in the rooms to maintain a temperature of 36 deg. F. It was also required that each plant must include the necessary distilling and filtering apparatus for supplying pure water for the ice cans, which, considering the very dirty waters of the Mississippi, especially after its confluence with the Missouri—"Big Muddy"—was quite essential. The advertisement for proposals brought in a number of bids. But after canvassing all the tenders, the award was finally made to the Memphis Machine Works, of Memphis, Tenn., who were the lowest responsible bidders complying with all the requirements of the army engineers.

In a recent discussion before the Philadelphia Engineers' Club, Mr. Falkenau said: "I might tell of a rather peculiar experience out in Colorado, where they had a compressor running a number of drills. It failed, and after being overhauled by a certain engineer, I was called in some time afterward. They complained bitterly about the condition the compressor was in. They could not obtain the volume of air required to run one drill decently. On looking at the engine it appeared to me that the cylinder was extremely long for the throw the crank had, and I asked whether that was the original crank. The superintendent answered that it was. The engineer happened to be close by, and stated that the crank had been changed by him. It was a Clayton compressor, in which a thin layer of rubber about 1-6 of an inch thick was used under the valves. Upon investigation I found that these rubbers had given out, and some bright engineer, in order to make the compressor go—he had not time to wait for the proper rubber disks to come from New York, as it was out in Colorado—got some rubber pump valves about ⅝ or ¾ of an inch thick and put them under the inlet valves. The inlet valves are next to the piston. When the piston came up, it struck these valves; to avoid this, he put in a new and shorter crank, giving 1¼ inch clearance, which, of course, explained why the efficiency was so poor. I pulled out the valves, resurrected the old crank shaft, ground the valves to a metallic seat, and telegraphed for new rubbers. The metallic seat is used generally. I think Ingersoll used the metallic seat. After the rubber was inserted, of course the efficiency rose at once, and they were able to run three drills."

The "Bostedo" Foot Power Pneumatic Dispatch Tube System are carriers of cash, mail, messages, orders, or small parcels from one point to another, about buildings. They carry speedily, noiselessly, with great economy, and absolute security.

The simplest carrier in existence because there is no bearings, wheels, cords, pulleys or strained wires—only a smooth tube, through which the cartridge must travel with meteoric speed. The Bostedo tubes are operated by a law of nature. Bostedo tubes are automatic. Breakdowns and delays are unknown.

They make a neat appearance where they connect at stations, otherwise they are out of sight and can be adapted to any building.

They are not experimental. Public message carrying systems were established in London in 1849-50, Paris and Berlin 1850. Their merit is attested by the constant extension of lines in other large cities of Europe and America.

Systems are usually installed so that the pipes radiate from a central office to each department. Mistakes only occur through the carelessness of the operator.

They have a much greater carrying capacity than any overhead carrier.

The system can be made either vacuum or pressure, according to requirements.

Vacuum systems are sometimes operated by exhaust steam without the use of a blower.

Steam, gas, electric, foot or water power may be used to operate the system, whichever is cheapest and best available.

The repairs are practically nothing as there is nothing to wear out except the carriers.

All results are guaranteed by the company. They cost less than other systems for results obtained.

They are either sold outright or leased for a term of years, with option to purchase at any time during the term of the lease.

By applying to the Bostedo Pneumatic Tube Co., New York, Chicago, Boston, San Francisco, London, England, Sydney, N. S. W., full information can be obtained. dence.

The Emerson Electric Manufacturing Company are showing an electrically operated air-compressing outfit for physicians' use with atomizing tubes in treating mouth, throat and lung diseases, and which is also adapted for dental purposes, such as cleaning cavities in teeth. The outfit consists of a single-action-piston air pump with metallic ball valves operated by an alternating-current motor, connected by two feet of pressure hose to a six-gallon nickel-plated tank, which is supplied with a gauge to show the pressure, and stop-cocks and hose connections for leading off to the atomizing tubes, etc. It is asserted that this pump will compress air up to about 30 pounds pressure, but that it is more efficient up to about 20 pounds pressure, which is understood to be about the right amount for this class of work. The pump has a capacity of about 1½ gallons of free air a minute, and will pump the six-gallon tank, it is claimed, up to ten pounds pressure in 2½ minutes, 15 pounds in 4½ minutes, 20 pounds in 6½ minutes, 30 pounds in about 14 minutes.

The manufacturer says that this style of outfit is not only much more convenient than any water-pressure air pump, but in most cases will cost much less to operate, and has the additional great advantage of being able to get the pressure anywhere that it is desirable. No permanent fixtures are necessary for fitting up this outfit, as all that is necessary to start it in operation is to plug in the lamp socket the same as an electric lamp or an electric fan motor. The expense of operating the pump is said to be very small, as at the ordinary rates charged for an electric-light current of 20 cents for 1,000 watts it would cost less than one-fourth of a cent to pump this tank of air up to 20 pounds' pressure. All of the parts of this outfit are extremely simple and durable, the pump having long, heavy bearings, and the valves being metallic, the only part of the pump which might require renewal after a considerable length of time being the leather packing of the piston, but this can be replaced by any one in a very few minutes and at a cost of a few cents. The outfit is placed on the market by the Emerson Electric Manufacturing Company, of St. Louis, Mo.

There has recently been opened at Staines, England, on the Middlesex side of the Thames River, a new system of sewage disposal which, in connection with the old sewerage works, affords an interesting example of the application of compressed air in sewerage works. The town has a population of about 7,000 and is underlaid by a gravel formation containing much water. To keep this from the sewers, and at the same time avoid expensive excavation, cast-iron pipes were used, and the Shone system of district

pumping stations was adopted. The sewage was forced from the town by a Shone ejector to a disposal site, where it was treated by a bacteria process. The dry-weather discharge is about 180,000 gallons per day, and this quantity ought not to be materially increased during rainfalls, because surface water is excluded as far as possible.

Two years ago the site of the disposal works was acquired for a large storage reservoir to be constructed by some of the London water companies, so the town authorities retained Mr. J. S. Melliss to design a new system of disposal. It is this which was recently opened, and from the interesting description of it in the "Surveyor," the following notes have been prepared:

The disposal works are about four miles from the most distant ejector station, and there is a difference in elevation of 31 feet between the two points. The old air compressing plant was inadequate for increased service, so a new station had to be constructed. The new works accordingly comprise 1½ miles of 12-inch cast-iron force main, a similar length of 4-inch cast-iron air pipe, power station and chemical house, two precipitation tanks with a combined capacity of 240,000 gallons, 26 acres of land underdrained at an average depth of 5 feet to serve as filter beds, and an effluent drain two miles long from the filters to the River Ash.

All the operations of lifting the sewage, mixing the chemicals, pressing the sludge and pumping water are performed by compressed air, steam being used only for the compressors and a 4½-horse-power engine running the lighting dynamo. The principal machinery is provided in duplicate. There is a pair of low-pressure compressors supplying air to the ten ejector stations in the town and an intensifier for sludge pressing. The low-pressure compressors are of the straight-line type, with 10-inch steam cylinders and 18-inch stroke and 11-inch air cylinders, also of 18-inch stroke. The air valves are operated mechanically and are stated to work without noise when the engine is running at 200 revolutions per minute. The compressors deliver air at about 36 pounds pressure to a steel tank 4 feet in diameter and 12 feet high, connected to the mains running to the city. The intensifying engine takes air from the low-pressure main and raises it to 100 pounds. It has a 6-inch steam cylinder, 5-inch air cylinder, a stroke of 8 inches, and is fitted with mechanically-operated valves stated to work silently at a speed of over 500 revolutions per minute. The air is discharged into a receiver 2½ feet in diameter and 8½ feet high, from which it is piped to the press.

The sewage on reaching the works is screened and then treated with crude sulphate of alumina, salts of iron, carbon and lime. The sludge is sold, after being pressed into cakes, at about 60 cents per one-horse carload, and is stated to find a ready sale as a fertilizer. The works are now operated under the direction of Mr. E. J. Barrett, the surveyor to the Council.

The increasing use of compressed air in connection with the employment of pneumatic tools and for other purposes has been the means of reviving the interest taken in the question of production and application of compressed air for power purposes.

In the case of the transmission of power by water pressure the power given off by a motor cannot exceed the product of the pressure multiplied by the volume of water used.

With air, however—an elastic fluid—when used expansively, the power can be, and generally is, greater than the product of pressure and volume, the pressure and volume being those in the supply mains. Again, the work done against friction in forcing air through the mains is not altogether lost, as the heating effect due to friction tends to reduce the cooling effect due to expansion. Notwithstanding this, it is advisable to make the mains carrying the air as large as practicable, in order that the loss of pressure shall be small. For economy, especially in the larger type of compressed air motors, there is a considerable advantage in heating the air before being used in the motor; but in the case of small pneumatic tools it is probably hardly worth doing.

With reference to the best form of compressor to be used, it may be stated generally that for pressure above 70 lb. to 80 lb. per square inch it is advisable to compress in two stages—that is, the air at atmospheric pressure is drawn in and compressed to an intermediate pressure in the first cylinder, and from this it passes to the second cylinder, where it is compressed to the final or working pressure.

Moreover, it is important that the air supplied to the compressor should be as cold as possible, and if there is any convenient and economical method at hand for cooling is so much the better, since the colder the air the greater the output of the compressor; further, it is very important, especially for the smaller class of drills and motors having a number of small pistons and valves, that the air should be as free as possible from dust and grit, to prevent damage from cutting to the numerous moving parts. As to the cooling of the air during compression, no doubt for those smaller pneumatic tools which have to be held in the hand during operation it is advisable to cool by means of a water jacket surrounding the air cylinder, and not by injecting a spray of water into the cylinder. The latter is a very efficient means of absorbing the heat which is generated during compression, but the air leaves the cylinder in a more or less saturated condition. When this saturated air expands at the exhaust apertures of the tool, heat is absorbed, and the cold produced frequently forms ice in the exhaust passages and outlet, where the expansion takes place. This may be avoided by heating the air before it enters the tool, as previously pointed out, but in small plants this is seldom done, and hence it is advisable to keep the air as dry as possible.

The capacity of the compressor should be amply large for the work it has to do, since it is not economical to run it at high speed. Again, the clearance spaces should be as small as possible, especially if the pressure is at all high, and only one cylinder is used to produce the pressure. If injection spray is used, relief valves should be fitted, or water may accumulate and the cylinder end be knocked out. For riveting, a pressure of 100 lb. to 120 lb. per square inch is desirable for good work, but for drilling less pressure could be adopted.

Moreover, the question of keeping the pressure up to its maximum is very important, as bad work can easily be turned out by a good tool if the pressure is allowed to drop, and further, a reservoir of good capacity is of considerable service in keeping the pressure steady.

As to the consumption of air by the various pneumatic tools now on the market, it appears that for a given amount of work it varies as much as 25 per cent. among the different types, a result probably due, in a great measure, to the different degrees of air expansion allowed in the various tools.

A valuable feature in connection with any installation of compressed air is the absence of the necessity for providing exhaust pipes, the exhaust air being rather an advantage than otherwise, especially in the case of mines and quaries, and none the less in shops with a vitiated atmosphere.

Compressed air has been applied with considerable success as a motive power for tramways. In this case a storage cylinder is employed in which the air is stored at a considerable pressure and of sufficient volume to last for a complete journey of the tramcar, and when exhausted is refilled with air at the pressure stations. Here, again, the exhaust is delivered freely into the street and creates no nuisance, which cannot be said of many of the motor cars which exhaust their burnt products of petroleum or spirits behind them.

For many purposes there is no doubt that compressed air has much to commend it, not only economically, but hygienically. —*The Practical Engineer.*

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing o inions.

We request that the rules governing such corre spondence will be observed, viz.: all communica tions should be written on one side of the paper only; they should be short and to the point.

COMMUNICATIONS.

A short time since we received a letter from a gentleman connected with the construction and repair department of one of the prominent railways asking if pneumatic tools could be used for chiseling and gouging wood.

One of our correspondents to whom we repeated the question has kindly replied as follows:

"We are in receipt of yours of the 1st, and in reply, would say that we suppose you wish to use chisels and gouges for working wood.

"We have tried this with considerable success and would be able to give you a better opinion as to whether it would work in this special case if we had additional information on the subject as to what the work is like, the kind of wood used, the amount of material to be removed at one cut, etc. The chief point

in using pneumatic tools for cutting wood is, the blow is so rapid and powerful that the wood does not offer enough resistance to the chisel to keep it in the hammer unless the wood is hard and a very large cut is taken.

"We should be glad to take the matter up further when we have additional advices from you."

We think this is a subject likely to be of interest to many of our readers and suggest that any who have had experience in this direction, send a reply to this.

Chicago, U. S. A., April 30th, 1901.

COMPRESSED AIR, 26 Cortlandt St., New York City.

Gentlemen:—We wish to advise you that Mr. James H. Manning, formerly Master Mechanic of the Union Pacific R. R. Co., at Cheyenne, Wyo., has been appointed our Western Manager, with offices at San Francisco, Cal., where a complete line of our "Little Giant" Pneumatic Tools and Appliances will be carried in stock, in order to supply the rapidly increasing demand for these machines upon the Pacific coast expeditiously. Very truly yours,

STANDARD PNEUMATIC TOOL CO.

Marion, O., April 29, 1901.

COMPRESSED AIR:

Can compressed air be applied for power for passenger and freight elevators in office buildings and warehouses? The elevator to be driven by direct piston; piston running down in the earth say ninety feet, and elevator, eighty feet.

Give me all particulars and cost of fuel for one elevation of 1,500 feet, counting soft coal at $2 per ton, and gasoline at 10 cents per gallon.

An early reply will oblige,

Yours very truly,

E. HUBER.

There is no reason why air cannot be used for operating elevators in warehouses, using either the Direct Piston method or the Multiple System, which will be described later.

In Paris in the large apartment houses there are perhaps hundreds of elevators running on this principle (direct piston) using water under pressure, however.

There are two factors on which the success of a system of this kind must depend. The first is that a fairly high pressure is necessary in order to keep the lifting piston rod as small as possible. The second is that air is an elastic fluid which makes it difficult to stop a car exactly where it is wanted. An example of this is afforded by hydraulic elevators "bouncing" when air gets in the hydraulic cylinder. This latter factor is nearly prohibitive except for low speeds. Further the direct piston can only be used for comparatively low lifts.

There are many applications of the pneumatic hoists for use in shops, but the lifts in these cases range from 4 to 10 feet. With these, on account of the slow speed, very close adjustment can be made, so close, in fact, that these hoists are generally used in foundries for handling moulds.

In the case of elevators for high lifts, it would be advisable to use a system of Multiple Shives such as is employed for high speed hydraulic elevators. In this type a large cylinder has mounted on one end a number of shives while to the end of the piston rod is attached a crosshead also carrying a like number of shives. A lifting cable winds around these shives or pulleys and finally up over the head shive and down to the elevator. A multiplication of possibly 10 or 12 times is thus effected depending upon the number of shives, so that a piston movement of one foot will lift the car perhaps 10 feet.

Reducing these two methods to figures to obtain some idea of the amount of air required and the consequent cost for which the correspondent asks, we have

Direct Lift System.

Assume an 8″ lifting tube for a lift of 90 feet.

LOAD.

Tube	2,700	pounds
Useful load	1,500	"
Platform	500	"
Addition for safety	1,300	"
	6,000	pounds

Assume air at 100 pounds pressure per square inch.

Our piston therefore must have 60 sq. in. area. An 8″ pipe about fulfills this condition having an area of .3591 sq. ft. or 50. sq. in.

Assume an 9″ pipe for the cylinder in which this piston works; are a .4418 sq. ft.; 90 ft. in length; equals 39.76 cu. ft. of air for a complete lift. Allow this rise to oc-

cur in one minute and we must have 39.76 cu. ft. of air or a pressure of 100 pounds or 39. 76 × 7.8 — 320. cu. ft. free air per minute on the assumption that the elevator makes one lift every minute. As practically the same time will require to descend as to lift, we can count on a compressor of half this capacity as sufficient.

It is further advisable to have a receiver sufficient to hold possibly double the air required by the tube—assuming a receiver 42 inches by 10 ft., this would have a capacity of about 96 cu. ft.

Assume the compressor running continuously. A compressor with a capacity of 177 cu. ft. of free air per minute is more than sufficient as the elevator would very likely not work on an average over once every five minutes. Our compressor would, therefore, run at very much reduced speed and would average possibly 25 H. P.

Assume the compressor running non-condensing. Steam consumption will be about 35 pounds of water per I. H. P. per hour, or 875 pounds of water per hour or 8,750 pounds in 10 hours.

Assume 10 pounds of water evaporating per pound of coal 87.5 pounds per hour, or 875 pounds per day of 10 hours, approximately ½ ton of coal per day, or $1 for coal. Allow for engineer at $2 per day, incidentals such as oil waste, etc., etc., 50 cents, and 66 cents per day for interest and depreciation. We have a total approximate daily cost of $4.16. Of course, if other machinery is being operated at the same time, there will be no cost for engineer.

Using a gasoline engine with gasoline at 10 cents per gallon, for approximate figures, you may assume a 30 H. P. engine which will average 1.25 quarts of gasoline per H. P. per hour, or 93½ gallons, or $9.35 for gasoline.

The Second Method

Assume useful load	1,500	pounds
Platform	500	"
Cable, etc	1,000	"
Total	3,000	pounds

Consider a multiplication of 8 times, then our cylinder must be 11 ft. long and the power must be 8 times as great.

$$3{,}000 \times 8 = 24{,}000 \text{ pounds.}$$

Assume air at 100 pounds pressure. We must then have 240 sq. in. in piston, which means 17½" in diameter.

A cylinder 17½ inches in diameter and 11 ft. long holds 18¼ cubic ft. to fill, which at 100 pounds pressure, requires about 142 cu. ft. of free air. If the elevator makes one trip per minute our compressor must have a capacity of 142 cubic feet per minute. However the cost of operating this system will be practically the same as the Direct Lift.—EDITOR.

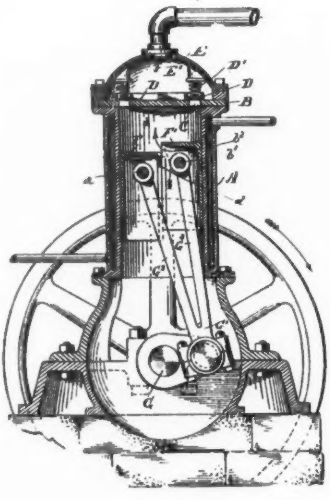
U. S. PATENTS GRANTED FEB. 1901.

Specially prepared for COMPRESSED AIR.

671,044. AIR-COMPRESSOR. George S. Binckley, San Francisco, Cal., assignor of one-half to Willis G. Dodd, same place. Filed June 27, 1900. Serial No. 21,818.

A compressor, the combination with the compressing-cylinder, of the piston working therein, said piston consisting of independently relatively movable sections, and of separate pivoted connections between the drive-shaft and the respective sections of the piston for imparting a reciprocating motion to the piston and moving its sections toward

and from each other during the strokes of the piston, the movement of the piston-sections being dependent upon the angularity of the pivoted connections during the revolution of the drive-shaft.



671,207. SAFETY APPLIANCE FOR AIR-BRAKES. Allan Cowperthwait, Brooklyn, N. Y., assignor to Alonzo B. See and Walter L. Tyler, same place. Filed Feb. 4, 1901. Serial No. 45,826.

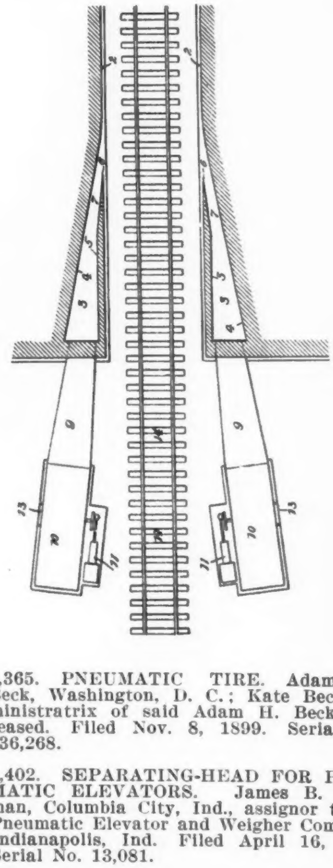
671,209. COMPRESSED-AIR PUMP. Ralph W. Elliott, Oakley, Cal., assignor of one-half to Frank P. Baker, same place. Filed Dec. 17, 1900. Serial No. 40,183.

671,239. PNEUMATIC SELF-ACTUATOR FOR MUSICAL INSTRUMENTS. Henry Schwesinger, Detroit, Mich. Filed May 31, 1900. Serial No. 18,494.

671,244. AIR-PUMP GOVERNOR. Samuel B. Stewart, Jr., Schenectady, N. Y., assignor to General Electric Company, of New York. Filed Jan. 21, 1901. Serial No. 44,320.

671,264. MEANS FOR VENTILATING TUNNELS. Charles S. Churchill and Charles C. Wentworth, Roanoke, Va. Filed Nov. 10, 1900. Serial No. 36,088.

A ventilating system for tunnels, the combination with the tunnel, of an air-chamber formed in the wall of the tunnel having its inner wall substantially in line with the inner wall of the tunnel and having an opening arranged to discharge air therefrom in a direction substantially parallel to the axis of the tunnel and adjacent to the wall thereof, and means for blowing a blast of air into said chamber, whereby the blast of air issuing from the chamber into the tunnel will create an induced draft through the tunnel.

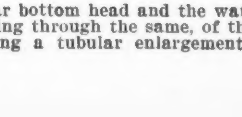


671,365. PNEUMATIC TIRE. Adam H. Beck, Washington, D. C.; Kate Beck administratrix of said Adam H. Beck, deceased. Filed Nov. 8, 1899. Serial No. 736,268.

671,402. SEPARATING-HEAD FOR PNEUMATIC ELEVATORS. James B. Schuman, Columbia City, Ind., assignor to the Pneumatic Elevator and Weigher Company, Indianapolis, Ind. Filed April 16, 1900. Serial No. 13,081.

671,428. WATER-RAISING APPARATUS. James E. Bacon, Richmond, Va., assignor to Bacon Air Lift Company, of New Jersey. Filed Jan. 14, 1895. Serial No. 534,-733.

The combination with the well-tube having



an annular bottom head and the water-supply tube passing through the same, of the uptake-pipe having a tubular enlargement and the

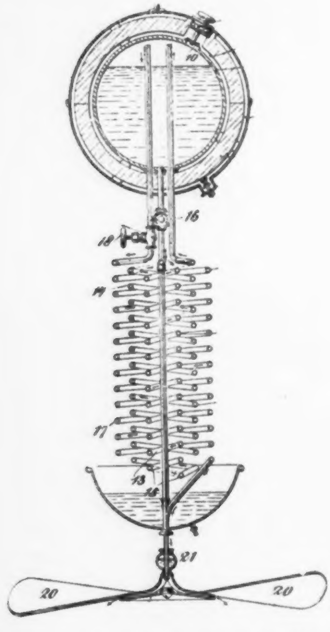
reducer between the enlargement and uptake-pipe and the supply-tube, the said supply-tube being slotted near its upper end.

671,535. PNEUMATIC TIRE AND WHEEL-RIM THEREFOR. Robert Bryan-Haymes, Kingsbridge, England. Filed Oct. 26, 1900. Serial No. 34,461.

671,559. PNEUMATIC POWER-CYLINDER. Nils O. Lindstrom, New York, Borough of Queens, N. Y., assignor to Alonzo B. See and Walter L. Tyler, same place. Filed Feb. 4, 1901. Serial No. 45,847.

671,608. LIQUEFIED-AIR MOTOR. Oscar P. Ostergren, Brooklyn, N. Y., assignor to the General Liquid Air and Refrigerating Company, of New Jersey. Filed Feb. 13, 1899. Serial No. 705,427.

The combination with a reservoir for containing liquefied air or other gas of a coil



connected at one of its ends with the reservoir below the level of the liquid therein, a return-coil parallel with the first coil, the two said coils being connected together at their lower ends, an air or gas operated motor, in communication with the upper end of said return-coil.

671,970. ROCK-DRILL. Henry Koch, Tarrytown, N. Y., assignor to Rand Drill Company, New York, N. Y. Filed Sept. 13, 1900. Serial No. 29,899.

671,986. ARMOR FOR PNEUMATIC TIRES. Bacon Wakeman, Fairfield, Conn. Filed Sept. 12, 1900. Serial No. 29,840.

671,987. PNEUMATIC PACKAGE-HOLDER. George H. Wall, Cadillac, Mich. Filed May 31, 1900. Serial No. 18,558.

672,073. PNEUMATIC TIRE FOR VEHICLES. Hugh L. Warner, Dayton, Ohio, assignor to Alden D. Clark, same place. Filed Sept. 27, 1900. Serial No. 31,237.

672,082. ROCK-DRILL. Louis T. Sicka, Denver, Colo. Filed June 28, 1900. Serial No. 21,921.

672,083. ROCK-DRILL. Louis T. Sicka, Denver, Colo. Filed June 28, 1900. Serial No. 21,922.

672,115. AIR-BRAKE. George Westinghouse, Pittsburg, Pa. Filed Aug. 1, 1900. Serial No. 25,538.

672,217. PNEUMATIC-TIRE-VALVE TOOL. Edward M. Noyes, Ashtabula, Ohio. Filed June 23, 1900. Serial No. 21,380.

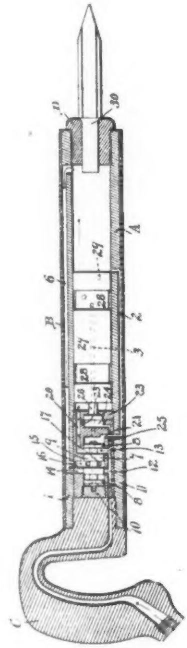
672,263. PORTABLE PNEUMATIC DRILL. William E. Dean, West Superior, Wis., assignor of one-fourth to Robert Kelly, same place. Filed Oct. 8, 1900. Serial No. 32,364.

672,277. PNEUMATIC TOY. James L. Maull, West Whiteland, Pa. Filed June 14, 1900. Serial No. 20,295.

672,306. PNEUMATIC TOOL. Thomas Barrow, Cleveland, Ohio, assignor to the Chisholm and Moore Manufacturing Company, same place. Filed June 6, 1899. Serial No. 719,563.

A pneumatic tool, the valve-box comprising the valve-bore, a constantly open port reversing and exhaust ports and a buffer-chamber connected with the said open port in combination with a buffer working in the buffer-chamber and a valve comprising a pis-

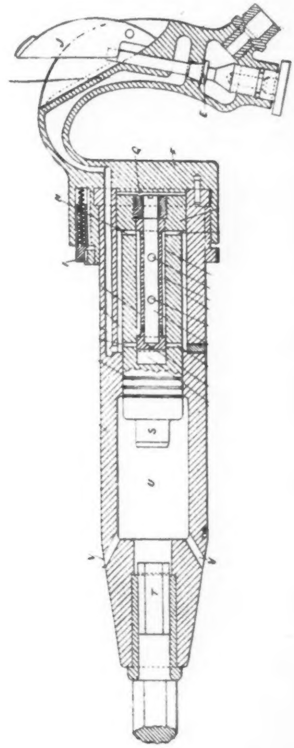
ton at each end and two intermediate slides adapted to register with the reversing and exhaust ports.



672,409. PNEUMATIC GRAIN-CONDUCTING APPARATUS. David Scheidegger, Woodburn, Ind. Filed July 2, 1900. Serial No. 22,283.

672,638. PNEUMATIC HAMMER. James Dunlop, Manchester, England, assignor to Charles Henry Schill, same place. Filed Feb. 26, 1901. Serial No. 48,951.

A pneumatic or like percussive hammer, in combination, a barrel or cylindrical body provided with passages for the supply of motive fluid under pressure, a differential piston fitted to slide therein, an annular space formed by the difference in the two diameters of the piston, a hollow inertia piston-valve fitted inside the piston, and having fitting parts at each end adapted to alternately cover and uncover almost simultaneously two sets of holes in the smaller diameter of the piston, the said inertia-valve having a set of holes between its fitting ends communicating with the space between it and the piston, and a single small hole in its end communicating with a small chamber formed between the valve and the interior of



the striking end of the piston, and an enlarged chamber with exhaust-ports beyond that part of the barrel which fits the smaller diameter of the piston.

A pneumatic or like percussive hammer having a barrel fitted with a differential piston, the combination with the inertia-valve L provided with a small hole P, of the chamber R and the motive-fluid passages and ports forming a fluid-pressure check at each end of the traveler of the inertia-valve.

672,732. PNEUMATIC STRAW-STACKER. George F. Conner, Port Huron, Mich. Filed May 3, 1900. Serial No. 15,378.

672,843. GRAVITY PNEUMATIC MALTING SYSTEM. Peter Renner, Cincinnati, Ohio. Filed Feb. 5, 1900. Serial No. 3,920.

672,905. RECEIVING-TERMINAL OF PNEUMATIC-DESPATCH SYSTEMS. Robert T. Jenney, London, England, assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Aug. 13, 1900. Serial No. 26,778.

672,970. ROTARY MOTOR OR PUMP. George Westinghouse, Pittsburg, Pa. Filed April 9, 1898. Serial No. 677,078.

672,971. ROTARY PUMP. George Westinghouse, Pittsburg, Pa. Filed April 9, 1898. Renewed Feb. 18, 1901. Serial No. 47,855.

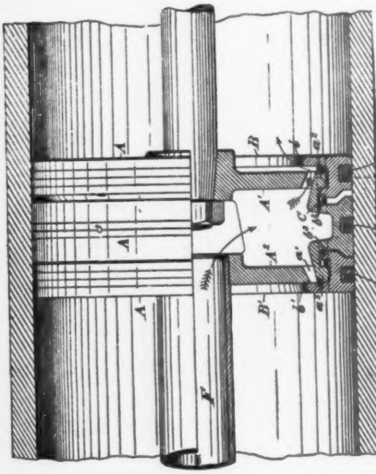
673,011. PNEUMATIC SPRING FOR VEHICLES. Warren W. Annable, Grand Rapids, Mich., assignor of two-thirds to G. Stewart Johnson and J. Warren Brown, same place. Filed Sept. 4, 1900. Serial No. 28,922.

673,055. PNEUMATIC TIRE. John Hubbard, Upper Holloway, England. Filed May 26, 1900. Serial No. 18,138.

673,063. PNEUMATIC SHOE-FORM. Harry A. Ruggles and Frank E. Wiesen, Milwaukee, Wis., assignors to Adda M. Becher, same place. Filed Oct. 25, 1900. Serial No. 34,340.

673,068. VALVED PISTON. John P. Simmons, San Francisco, Cal. Filed June 14, 1898. Serial No. 683,452.

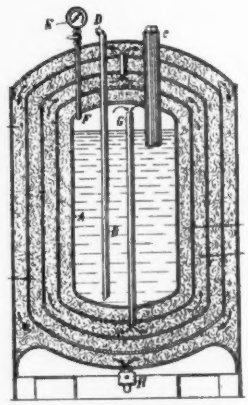
An air-compressor, the combination with a cylinder, of a piston therein comprising a



bearing-surface in contact with the interior of the cylinder, a reduced portion at the side of the bearing-surface, a port in the reduced portion running longitudinally of the cylinder and means movably connected to said reduced portion adapted by frictional contact with the cylinder when the piston is worked back and forth, to open and close the port in the piston.

673,073. RECEPTACLE FOR CONTAINING LIQUID AIR OR OTHER GASES. Gabriel A. Bobrick, Los Angeles, Cal. Filed Nov. 8, 1900. Serial No. 35,879.

A containing vessel for liquid air or other gases, comprising in combination an inner compartment and a series of concentric outer compartments each completely surrounding

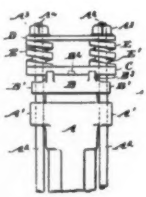


and inclosing the inner compartment, the alternate outer compartments being connected in series with the inner compartment and with the outer air respectively, to form a passage for the escape of expanding air or gas.

673,104. ROCK-DRILL. Warren Wood, Paterson, N. J. Filed Jan. 15, 1901. Serial No. 43,366.

A rock-drill, the combination of a cylinder having guide-lugs, a top head and its guide-lugs, side rods extending through the lugs of each, a cross-piece mounted on said top head and engaging said side rods, and means for locking said cross-piece and top head against movement relatively to each other,

and means serving with said side rods to hold said cross-piece and top head to said cylinder.



A rock-drill, a cylinder and its guide-lugs, a top head and its guide-lugs, and side rods extending through and beyond said lugs, a boss B^2 and holding-lugs B^3 B^3 on said head, and a cross-piece matching between said holding-lugs and having a recess *c* receiving said boss, and engaging said side rods, and means serving with the latter to hold said cross-piece and top head to said cylinder.

The cylinder A, and guide-lugs A′ A′ thereon, the top head B and its guide-lugs B′ B′ the boss B^2 and holding-lugs B^3 on said head, in combination with the cross-piece C matching between said holding-lugs and having the recess *c* receiving said boss, and the holes C′ C′, the side rods A^2 A^2 extending through said guide-lugs and holes, spring-plate D, springs *e e* and holding-nuts A^3 A^3.

673,133. PRESSURE-REGULATOR. Arthur R. Bullock, Cleveland, Ohio. Filed Sept. 18, 1899. Serial No. 730,825.

673,217. AIR-VALVE FOR RADIATORS. Doctor F. Morgan, Chicago, Ill., assignor to Scovill Manufacturing Company, Waterbury, Conn. Filed July 16, 1900. Serial No. 23,795.

673,259. MEANS FOR REGULATING SIZE OF COMPRESSION-CHAMBERS OF GAS-ENGINES. Camille Hautier, Paris, France. Filed Oct. 16, 1899. Serial No. 733,785.

673,319. AIR AND VACUUM VALVE FOR RADIATORS. Walter H. Duer, Fond du Lac, Wis. Filed June 30, 1900. Serial No. 22,146.